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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 83, NO. 4, pp. 253–260 JULY, 1956

CUCURBITA MIXTA, PANG. ITS CLASSIFICATION AND RELATIONSHIPS[1]

HUGH C. CUTLER AND THOMAS W. WHITAKER

Cucurbita mixta is the least known of the four squash and pumpkin species commonly cultivated in the United States. The Indians cultivated it prior to 1492, and several varieties are widely grown in the warmer parts of the country but the species was until recently considered a variation of *C. moschata*. Pangalo (1930) originally described it from material collected by Russian plant expeditions to the New World. The first useful description of the species in English was published in 1950 (Whitaker and Bohn 1950). It is likely that *C. mixta* will become better known when the virtues of this species are fully appreciated. Like *C. moschata*, *C. mixta* grows well in warm weather. In a test of flavor of about 85 kinds of pumpkin and squash, grown near Chicago, Cutler and Rhodes (unpublished data) found that well ripened Japanese Pie and some strains of Green Striped Cushaw, both varieties of *C. mixta*, ranked not far behind the five best flavored squashes. The best quality squashes are varieties of *C. maxima*. However, *C. maxima* is not adapted to warm summers, and its soft stem and peduncle are quickly attacked by squash borers (*Melittis satyriniformis* Hbn.). On the contrary, varieties of *C. mixta* do well under high temperatures, and are resistant to squash borers, while the flavor is almost as good and the fruits have a storage life equal to most varieties of *C. maxima*.

Nomenclature and description. CUCURBITA MIXTA Pangalo in Bull. Appl. Bot. Genet. & Plant Breeding 23 (3): 258, 1930.

C. mixta stenosperma Pangalo *ibid.*

C. mixta cyanoperizona Pangalo, *ibid.*

C. argyrosperma Hort., ex L. H. Bailey in Gentes Herb. 7: 457. 1948.

Since Pangalo did not designate a type specimen for his new species, we have selected an herbarium specimen grown from commercial seeds of Green Striped Cushaw, a variety similar, if not identical, to the most common variety grown in late pre-Columbian times by the Pueblo Indians of Arizona and now grown widely through the Southern United States (fig. 1). The fruit pictured in the upper left of figure three in Pangalo's paper is similar to this variety. The specimen, collected by Cutler and Whitaker, is deposited in the herbarium of the Missouri Botanical Garden.

[1] We wish to thank the officials of the John Simon Guggenheim Memorial Foundation for a grant which made this work possible.

[THE BULLETIN for May–June, 1956 (83: 183–251) was issued May 28, 1956]

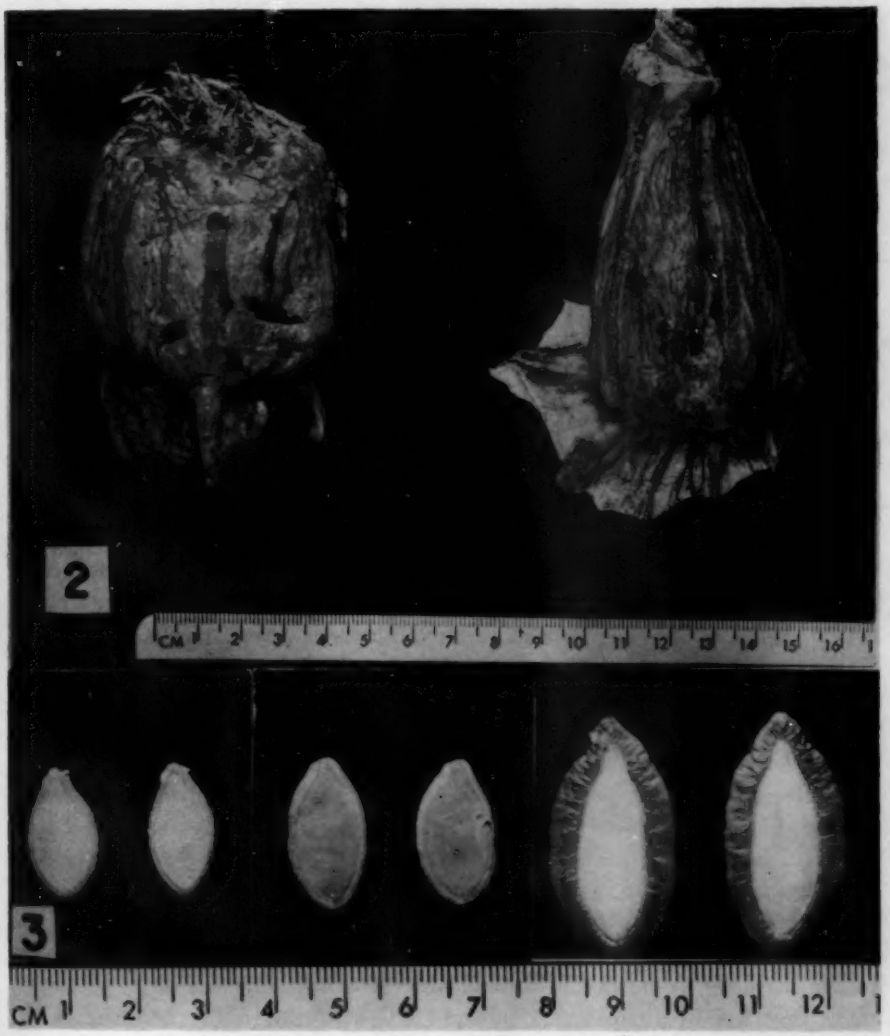
Plant annual, frost sensitive and intolerant of cool temperatures; vine pilose, not harsh, to almost glabrous; stem hard, five-angled; leaf large, broad cordate to cordate-ovate, shallowly to moderately lobed with broad, obtuse sinuses, with (or rarely without) whitish blotches, margins irregularly denticulate, major veins frequently with corky thickening; corollas yellow to yellow orange, often conspicuously striate, broad apiculate lobes, closed the evening before anthesis; androecium usually long and slender, columnar; stigmas large, bright yellow to orange or green, rough; young peduncle pilose, angled and clasping the fruit like that of *C. moschata,* mature peduncle usually moderately hard, corky, basically five-angled, the five angles may be represented only by five smooth lines, although when the stem is greatly expanded the slight enlargement at the fruit is usually concealed by firm, warty cork that slightly to greatly increases the pedun-

FIG. 1. Fruits of *Cucurbita mixta* var. Green Striped Cushaw showing peduncle and corky ridges at stem end of the fruit (courtesy Lawrence Robinson & Sons).

cle diameter; (fig. 2) fruit variable, hard or soft-shelled, usually dull in color, often with warty edges or bumps especially near the peduncle, and extending as ridges over the stem end of the fruit; fruit flesh usually moderately dry, white to pale tan or yellow (orange unknown), coarse grained with coarse but not gelatinous fibers; placenta collapsing at maturity; seeds separating readily and clearly from the plup; plump, usually ovate ellipsoidal, with symmetrical or slightly asymmertical, obtuse funicular attachment (fig. 3); seed body white, soft, usually split in various patterns, or tan, smooth and hard; margin barely scalloped, separating into threads, or threads adhering together, sometimes thin and of a different color from the body of the seed, or the margin greatly enlarged, silvery-green or silvery-blue.

Like maize and several other cultivated plants, the species of *Cucurbita* have many variations which can be combined in numerous ways. Certain

combinations may be most common in definite areas, yet, because there are many combinations of characters and because the varieties are frequently found far from the centers in which they are most abundant, it



FIGS. 2–3. Peduncles and seeds of *Cucurbita mixta*. FIG. 2. Peduncles of *C. mixta;* left—Japanese Pie, right—Green Striped Cushaw. FIG. 3. Seeds of *C. mixta;* left—Green Striped Cushaw, center—Taos, right—Silverseed Gourd.

is usually futile to describe definitely a kind of squash and give it a scientific subspecific designation. All three of the synonyms cited above are based on seed characters. These characters are inherited independently

and appear to be almost valueless for delimiting botanical varieties as are colors or endosperm characters in maize. Yet in the past, before extensive movement and mixing of *Cucurbita* species and varieties occurred, seed characters probably were associated with certain kinds of squash. We can distinguish three types of seeds in *C. mixta* ("green striped cushaw," "taos," and "silverseed"). Most common and most widespread is the "green striped cushaw" type with quite large (1.0×1.1 mm. to 1.6×0.9 mm.), soft, white-bodied seeds found in the Green Striped Cushaw and Japanese Pie squashes of today, in many Mexican varieties and in most of the *C. mixta* in the Southwest grown by present-day Indians and found in late pre-historic ruins. "Taos" type seeds (2.2×1.2 mm. to 2.0×1.1 mm.), closely resemble those of the Banana varieties of *C. maxima* and are known from Mexico, from a few fruits collected at Taos and several other Rio Grande Pueblos and from late pre-historic sites in the same general region. The "silverseed" type (3.5×1.8 mm. to 3.3×1.8 mm.), is found in Mexico.

Below we have classified according to seed type all the varieties known to us: "green striped cushaw"—Green Striped Cushaw, Tennessee Sweet Potato, Puritan, White Cushaw, Chirimin, Japanese Pie, Kikuza, Saikyo, Yokohama, and most Mexican mixtas; "taos"—Taos; "silverseed"—Silverseed Gourd.

When young, the peduncles of *C. mixta* resemble those of *C. moschata* and *C. ficifolia*. As the peduncle matures, a corky secondary thickening develops so that it is somewhat similar to the corky cylindrical peduncle of *C. maxima*.

In his analysis of the differences which separate *C. mixta* from the other annual cultivated species, Pangalo (1930) found that 13 were like *C. moschata*, 9 like *C. pepo*, and only 4 were similar to *C. maxima*.

Genetic relationships. The genetic affinity of *C. mixta* to the other cultivated species of *Cucurbita* is confused, primarily because it has only recently been recognized as an independent species (Pangalo 1930). Breeders formerly lumped this species with *C. moschata*. As a result, unless varietal names are given, it is difficult to obtain a clear picture of the interspecific breeding behavior of this entity. Nevertheless, some significant data have been accumulated which suggest tentative relationships.

C. mixta x C. pepo. L. H. Bailey (1902) produced the first successful interspecific cross to be reported in *Cucurbita*. Baily obtained two fruits with fertile seed by pollinating Connecticut Field Pumpkin (*C. pepo*) with Japanese Crookneck (*C. mixta*). Eighty-eight F_1 plants were grown from the seed of these two fruits. Evidently the F_1 was fertile, or at least sparingly fertile, since Bailey reports that a number of F_2 plants were grown. However, the F_2 plants must have been very nearly sterile as only

one fruit was produced; no mention was made of it having seed. Castetter (1930) secured one fruit with numerous fertile seed in a cross using Connecticut Field Pumpkin (*C. pepo*) as the pistillate parent and Striped Cushaw (*C. mixta*) as a pollen parent. The F_1 plants were vigorous and healthy, but it is unlikely that they were fertile as no record was made of this feature. Van Eseltine (1937) reports that he obtained fruits from Delicata and Giant Crookneck (*C. pepo*) when pollen from Japanese Pie (*C. mixta*) was used. Whether or not the fruit contained viable seed was not stated. He also obtained fruit from the reciprocal cross using Japanese Pie (*C. mixta*) as the pistillate parent with pollen from Delicata, Giant Crookneck, and Golden Custard (all *C. pepo*).

From the above data, we can draw the conclusion that if the proper combinations are used, along with a great deal of persistence, it is possible to obtain hybrids between *C. pepo* and *C. mixta;* but fertility in the F_1 is variable, and the F_2 is mostly sterile. Evidently the cross is more likely to succeed if a variety of *C. pepo* is used as the pistillate parent.

C. mixta x C. maxima. Halsted (1908) has reported that he obtained a fertile hybrid by crossing Striped Cushaw (*C. mixta*) with Delicious (*C. maxima*), using Striped Cushaw as the pistillate parent. F_1 plants were grown but the experiment was apparently terminated at this point. Castetter (1930) obtained 25 fruits and two fertile seed in matings between Striped Cushaw (*C. mixta*) and Marblehead (*C. maxima*). The F_1 plants were exceptionally vigorous, but completely pollen sterile. Some fruits were obtained by backcrossing to *C. maxima* var. Hubbard, but in no case were any viable seeds found in these fruits. Whitaker and Bohn (1950) indicate that *C. mixta* and *C. maxima* can be crossed in reciprocal matings, but with difficulty. An occasional fruit will set which may be seedless, have flat seeds with poorly developed embryos, or a few plump seeds may be found. The F_1 plants produce flowers that degenerate at various stages up to anthesis. An occasional flower will continue to anthesis, but only abortive pollen grains are produced. The female flowers are apparently normal, but are cross-sterile with pollen from either parent.

It is clear from the above work that interspecific hybrids can be obtained from reciprocal matings between *C. mixta* and *C. maxima*. However, the F_1 is male sterile, and cross-sterile, or nearly so, with each parent.

C. mixta x C. moschata. Because of the confusion in nomenclature, there is little precise evidence from the early breeders regarding this cross. Pangalo (1930) has reported *C. mixta* to be cross-sterile with *C. moschata*. Bohn (unpublished) reports that dissimilar results are obtained in reciprocal matings of the two species. When *C. mixta* is used as the male parent, the flowers that set have flat, abortive seeds with small embryos, or perhaps a few plump seeds. In the reciprocal mating the flowers

usually slough. If fruit set occurs, the fruit have only small flat seed with no, or poorly developed, embryos. During the summer of 1952 numerous pollinations were made using the variety Long Genoa Queen (*C. moschata*) as the pistillate parent and pollen from plants of a *C. mixta* seed collection from Mexico. Most of the flowers sloughed or the young ovary failed to develop properly and decayed. However, four fruits were obtained; one was parthenocarpic; one was poorly developed, with a few plump seeds; two were fairly well developed with a few plump seeds, some of them germinating within the fruit. In the reciprocal cross two fruits were obtained. The seeds were flat, numerous with small, poorly developed embryos. These data indicate that hybrids can be obtained between *C. mixta* and *C. moschata* but only if *C. moschata* is used as the pistillate parent.

When the plump seeds from the above successful matings were planted only two seedlings emerged and developed into mature plants. They were about intermediate between the two parental varieties with respect to the morphological characteristics of the vines and flowers. The fruits were oblong, oval (23 cm. long × 11 cm. wide), with orange skin color, mottled with dark green. The peduncle was somewhat similar to *C. moschata,* and not at all enlarged or corky like *C. mixta*. Male and female flowers were sparingly produced. Pollen fertility averaged 31 percent (scored as stainable pollen, from aceto-carmine counts). Comparable counts from *C. moschata* (L.G.Q.) the female parent, and *C. mixta,* the male parent were, 83% and 90% fertile pollen, respectively. Of 20 cells examined at 1M, the number of bivalents ranged from 11 to 18. Seventeen was the number most frequently found; the remainder were unpaired. Quadrivalents very rarely occurred. These cytological irregularities more than likely account for two-thirds of the pollen grains being sterile.

Four fruits were obtained from the F_1 plants; two by selfing and two by backcrossing to *C. moschata*. Of the selfed fruits, one contained a single seed, while the other had about two dozen seed, but they were slightly flat, the embryos not being fully developed. The fruit from backcrosses to the female parent (*C. moschata*) were devoid of seed, and were evidently parthenocarpic.

In a series of crosses, Rhodes (unpublished) obtained fruits from crosses between *C. mixta* and *C. moschata*. Using the mixta variety Green Striped Cushaw as the pistillate parent, and the moschata varieties, Kentucky Field and Butternut as staminate parents, he obtained several fruits from each mating with a few fertile seeds. Except for the Green Striped Cushaw markings on the fruit, the F_1 plants and fruit were remarkably similar to the moschata parent. The fertility of the F_1 plants was not determined.

Discussion. The evidence from morphology and the breeding tests suggests that *Cucurbita mixta* is separated from the annual cultivated species of the genus by clear-cut differences. Among the most obvious morphological differences are the hard, enlarged peduncle, and certain fruit characters, specifically the color of the flesh, and the collapsed placenta from which the seeds separate readily.

The data from interspecific matings of *Cucurbita mixta* with the other annual cultivated species indicate that sterility barriers have developed that for the most part prevent gene exchange between them.

Although there is good archeological material of cultivated cucurbitas from many sites in the New World, *C. mixta* does not appear until relatively late. The earliest material known is that from the Ocampo Caves, (Whitaker, Cutler and MacNeish, *in press*) tentatively dated as about 650 to 1050 A.D. *C. mixta* must have originated at a late date, perhaps as the result of hybridization of *C. maxima* and *C. moschata*. Its present area of distribution within the region in which *C. moschata* is common and north of the area of most *C. maxima* would account for its greater similarity to *C. moschata*.

There is no experimental work to indicate the relationship of *C. mixta* to the cultivated perennial, *C. ficifolia*, or to the wild perennial species of the genus.

SUMMARY

1. The nomenclature of *Cucurbita mixta* is reviewed, and a botanical description of the species based on the study of a number of varieties is given.

2. The varieties of the species are separated into three classes on the basis of seed type.

3. There is available sufficient evidence from hybridization experiments, to indicate that *C. mixta* is separated from the other annual species of *Cucurbita* by sterility barriers so effectively that its status as a good species cannot be questioned. The evidence from morphology leads to the same conclusion. Likewise, the results of interspecific hybridization suggest that *C. mixta* may be more closely related to *C. moschata* than to *C. pepo* or *C. maxima*. This is not surprising, since the geographical distribution of these two species points to the same conclusion.

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LA JOLLA, CALIFORNIA

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THE MORPHOLOGICAL AND CYTOLOGICAL DISTINCTNESS OF BOTRYCHIUM MINGANENSE AND B. LUNARIA IN MICHIGAN[1]

WARREN H. WAGNER, JR., AND LOIS P. LORD

This study was begun in 1949 when Prof. E. B. Copeland, Dr. F. S. Wagner, and the senior author encountered a large stand of a western moonwort resembling *Botrychium lunaria* (L.) Sw. near Jonesville, Butte Co., California. We tentatively identified this plant at that time as *B. minganense* Victorin, a taxon which most authors have come in recent years to regard as merely a trivial form of *B. lunaria*. However, Victorin's original interpretation of his new taxon (1927) was based on a very careful study. The question arose, therefore, whether his interpretation of *B. minganense* as a sharply distinct entity may not have been a valid one. But his original localities of the type material were in eastern North America. We hoped that an opportunity might arise in the future to examine more typical material of *B. minganense* growing in nature side-by-side with true *B. lunaria*, so that we could make a careful analysis of their distinctness.

In northern Michigan, during the years 1952 and 1955, it was found that both taxa grow together in the vicinity of the Biological Station of the University of Michigan. Not only do both entities exist here with each other in mixed populations, but each one has also been found growing alone in pure populations. Thus an excellent situation is available in this region to compare these plants, and to find out in what respects and to what extent they really differ.

Unfortunately at first the plant which we now confidently refer to *B. minganense* was mistakenly identified as *B. lunaria* f. *onondagense* (Wagner 1955, in connection with its chromosome number), an error which has occurred repeatedly in the past. This misidentification was corrected only after examination of Underwood's type specimen of *B. onondagense* and Victorin's type material of *B. minganense*. Now it seems certain that *B. minganense* is the name which should be applied to the commonest of the three moonworts in the Biological Station area. On the contrary, the California plant which we referred to *B. minganense* proves not to conform to that taxon, but its probable taxonomic status is still in question; it is very likely a distinct subspecies of *B. lunaria*. Although this problem will not be settled by this report, one point has emerged with considerable clarity: the taxon *minganense* seems on present evidence to constitute a species

[1] Contribution from the University of Michigan Biological Station.

distinct from *B. lunaria*, and the evidence for this view forms the groundwork of the following discussion. An effort has been made here to elucidate as fully as possible the morphological and cytological distinctness of *B. minganense* and *B. lunaria*, basing our conclusions especially on those Michigan populations with which we are most familiar.

In connection with this investigation, the senior author made a number of local field trips in the vicinity of the Biological Station in 1952 and 1955, and also drove by automobile to northern Michigan during the middle of May, 1955, to study the chromosomes of the two taxa at the time of meiosis. The junior author devoted a month in 1955 to collecting and measuring examples of the plants under discussion here, to determine how stable the ensemble of their distinctions would turn out to be.

Many of our problems of taxonomic interpretation of critical species of *Botrychium* result from the fact that the materials assembled to represent populations are commonly insufficient. The point has not been adequately emphasized that it is essential, in collecting grapeferns, to get a representative series of the population, because the range of variation within a species at a given occurrence is usually wide (Wagner 1946). Truly representative series are especially important since, as was emphasized in the recent monograph of the family Ophioglossaceae (Clausen 1938), the members of this family possess only a small number of comparative characters that can be used for taxonomic purposes. It is well-known, of course, that grapeferns are usually inconspicuous plants—so hard to find, in fact, that many are termed "rare" in local floras, when they are really frequent, or even common, once their habitats are recognized. However, if only single individuals, or a few, are discovered in a new locality, one can almost always depend on the principle that a number of others will be uncovered upon searching near by. And our experience indicates that careful cutting off of the leaves *above* the next year's leaf primordium that is contained within the common stalk—especially after "mid-season"—does not in any way damage a population, so long as this "pruning" does not extend more than a couple of years in succession.

Where taxonomic characters are as subtle and critical as those found in certain species-groups in *Botrychium*, it also becomes imperative to remove the specimens from the plant-press before they are dried, and to spread out the segments with fingers or forceps. All too often collections have been made in which the divisions of the leaf segments are hopelessly folded together, so that the mounted herbarium sheet is next to impossible to identify without removal and careful soaking.

Two moonworts that were later reduced to varieties of *Botrychium lunaria* have been described as new species from North America. Underwood (1903) described *Botrychium onondagense* as a species of rocky woods,

differing from *B. lunaria* in its "more slender habit and the distant cuneate segments;" and he suggested that it was close to *B. simplex* var. *tenebrosum*. *Botrychium onondagense* was later reduced to the category of variety by House (1923) and to a form by Butters and Abbe (1953); and it was interpreted as synonymous with *B. lunaria* f. *gracile* (Schur.) Aschers. & Graebn. by Fernald (1950, pp. 21, 22). Frère Marie-Victorin in 1927 described *Botrychium minganense* as a new species differing from *B. lunaria* especially in having larger spores, a more variable sterile segment, and in having a tendency to occur in clumps. Clausen (1938) discussed the two moonworts described upon American material, and he treated both of them as varieties of *B. lunaria*. He stated (p. 68) that "var. *minganense*" could not be maintained either as a species or a subspecies "since it is found almost throughout the North American range of *B. lunaria* var. *typicum*, and passes almost imperceptibly into that variety." Fernald (1950, p. 22) wrote that the plant he regarded as "f. *minganense*" was "barely separable" from *B. lunaria* f. *gracile* (syn. f. *onondagense*). Morton (1952, p. 16) described his *B. lunaria* var. *onondagense* as "a lax submembranous variety with rather remote segments," and his var. *minganense* as "scarcely distinguishable from the typical one." Our experience with taxon *minganense* conflicts with all these interpretations except that of Victorin.

Without the aid of Dale J. Hagenah of the Cranbrook Institute of Science much of this study would not have been accomplished. Marion T. Hall gave us some helpful suggestions. We also wish to acknowledge the field assistance given us by Edward G. Voss and Elizabeth M. Gage. The directors of the Gray Herbarium, New York Botanical Garden Herbarium, University of Michigan Herbarium, and Herbarium of the University of California at Berkeley, kindly sent their series of these plants on loan for comparison.

Populations studied in the field. The areas in which cytological collections were made are listed in Table 1. The detailed measurements of

TABLE 1. *Chromosome observations.*

	n
Botrychium lunaria L.	
5 miles S. of Pickford, Chippewa Co., Mich., May 15	45
Maple R. Dam, 1½ mi. SE of Pellston, Emmet Co., May 13	45
W. side of Mackinac City, Emmet Co., May 14	45
B. minganense Vict.	
5 miles S. of Pickford, Chippewa Co., May 15	90
W. side of Mackinac City, Emmet Co., May 14	90
4 mi. W. of Pellston, Emmet Co., May 15 (shade form)	90
Mud Lake, Sect. 18, T37N, R3W, Cheboygan Co., May 13	90
Grebe's Farm, Sect. 19, Mackinac Twp., Cheboygan Co., May 14	90
Riggsville Corners, Cheboygan Co., May 13	90
B. matricariaefolium A. Br.	
N. Central Sect. 33, Springvale Twp., Emmet Co., May 14	90
2 miles W. of Ayre, Emmet Co., May 14	90

leaves and spores for the scatter-diagrams were made of a series consisting of living material of *B. minganense* from Cheboygan County, Michigan, as follows: (a) 11 plants from a grassy area along the dirt road northwest of the border of Cheboygan, SW part of Sect. 15, T38N, R2W, (b) 13 from under brackens in a grassy area along the road, Mud Lake, Sect. 18, and (c) 23 from second-growth maple woods just south of Riggsville Corners; and of *B. lunaria*, 44 plants growing intermixed with *B. minganense* at locality "a" northwest of the border of Cheboygan. All of these areas are second-growth places, characterized usually by weeds like *Agrostis alba*, *Phleum pratense*, *Poa compressa*, *Satureja vulgaris*, *Potentilla argentea*, and *Euphorbia cyparissias*. Poison ivy, *Rhus radicans*, is often present. The bracken fern, *Pteridium aquilinum* usually supplies more or less of the shade on the more exposed situations; and in the more protected spots, the sugar maple, *Acer saccharum*, is the dominant source of shade. Especially productive localities throughout northern Michigan are found on the burned-over limestone outcroppings: here *Botrychium minganense* is especially characteristic, and it commonly grows even in the vertical crevices of denuded limestone pavements. Weedy knolls of limestone hills with scattered white cedar, *Thuja occidentalis*, tend to have either one or both of the moonworts, plus plants of *B. matricariaefolium*, *B. multifidum*, and *B. virginianum*. It is not uncommon to find all five species of *Botrychium* growing in the same colony; and to find any one of them at a new locality is to suggest that one or more of the others will be found there too. Of all of them, *B. lunaria* is actually the least common generally, although it is often abundant in its circumscribed habitats. *Botrychium minganense* is considerably more common as a rule than *B. lunaria* in our experience.

The only plants from the Biological Station area which we referred to *B. lunaria* f. *onondagense* were discovered growing in deep shade on the cool, mossy talus slopes of a limesink near Bolton, Alpena Co., Michigan, not far from numerous plants of *Cystopteris dickieana*.

The extremely attenuate, glaucous plant which we have observed in Alpena, Cheboygan, and Emmet counties, and which we consider to be the shade form of *B. minganense*, corresponding to f. *onondagense* of *B. lunaria*, occurs along paths and old roads and other disturbed forest floor situations in deep shade under maples, often with beeches and basswoods mixed in.

The single field observation of the California plant which has sometimes been identified with *B. minganense* was made west of Willow Creek, just below a dirt road about 1 mile northwest of Jonesville, Butte Co., California, at the upper end of a damp, springy meadow, the plants tending to grow on tussocks and "rises" around isolated trees where the ground was not so wet. The conspicuous genera growing near by were *Veratrum*, *Liparis*,

Hypericum, and *Mimulus*. *Botrychium simplex* also grew here, mixed with the other moonwort, and there was one plant of *B. multifidum*.

Morphological distinctness. Most of the differences between *Botrychium minganense* and *B. lunaria* are readily observed in the field. The yellow color of the lamina and stalk of *B. minganense* as it occurs in its usual habitats is highly characteristic, and it has been noted by all previous authors; *B. lunaria* differs in being decidedly greener—seeming bluish-green by contrast. The color contrast will be discussed in more detail below. Other contrasts of living specimens, in particular the orientation of the parts of the leaves, are almost entirely lost in herbarium specimens, yet the true three-dimensional arrangement is strikingly distinct. The sterile segments of *B. minganense* are more or less trough-shaped in the living plants, so that the pinnae or lobes are somewhat folded together, and the lowest several pairs of pinnae tend to embrace the base of the fertile stalk. In the spring this condition is very marked, especially in the middle of May at the time of meiosis. The segments of *B. lunaria* are flat during June, July, and August, and orientation of the pinnae analogous to that of *B. minganense* exists only during the beginning of the growing season in early May. Even then, however, the sterile segments very promptly begin to become plane except for the basal pair of pinnae. In what we regard as the deep-shade form of *B. minganense*, the pinnae retain the folded condition so strongly that the sterile segment is actually conduplicate (our field name for this form was the "conduplicate moonwort.") and the condition remains through the summer.

The "clumping" of plants which Victorin and subsequent authors have emphasized as characteristic of *B. minganense* does not seem to be of major importance as a criterion of this entity in northern Michigan. On the contrary, it is our view that "clumping" of plants may occur in any of the species of *Eubotrychium* under the influence of certain factors of the habitat. Of *B. minganense*, one especially striking and robust clumped plant was collected along a path near the limesinks at Leer, Alpena Co., in which the phenomenon was undoubtedly due to repeated lateral branching of the stem ("rhizome"). On the other hand, there is an excellent specimen of typical *B. lunaria* from Hannah's Head, western Newfoundland (*Fernald, Long, and Fogg 1168*, Gray H.) in which this species too is shown to form clumps by branching.

The colors of the living plants were estimated in the laboratory using Ridgeway's color standards (1912, pl. 31), and the results are shown below.

Species	Cress Green	Light Cress Green	Deep Chrys. Green	Chrys. Green	Chrom. Green
B. minganense		4	20	11	1
B. lunaria	1	39	2		

(What we consider to be the deep-shade form of *B. minganense,* however, departs from the usual yellowish character of that taxon: The color of the deep-shade form is glaucous green, not at all yellowish, and it seems probable that this difference is due to the habitat.) The coloration of these plants undergoes modification in the drying of herbarium specimens, of course, but surprisingly sharp distinctions often remain even in the dried state, and mixed collections will still retain the contrast between the two taxa.

Over-all leaf stature of these plants is approximately the same, but the total leaf length (including the fertile segment and the common stalk) of *B. minganense* is relatively greater in proportion to the length of the sterile segment than in *B. lunaria.* The whole leaf averages over 4.5 (2.0–8.0) times the length of the sterile segments in *B. minganense,* and 3.5 (2.0–6.0) times in *B. lunaria.*

The pinnae and lobes of the sterile segments of typical *B. lunaria* are borne more or less approximately, but in its shade forms (f. *onondagense*) they are occasionally quite distant (fig. 1, c), in some cases the pinna distance being greater than the greatest pinna breadth. In *B. minganense,* the pinnae are normally remote in all habitats, being especially far apart along the lower half of the sterile segment. Only rarely are specimens with approximate or overlapping pinnae found.

The angles formed by the upper and lower margins of the pinnae of the two entities average conspicuously different, and they are best contrasted by measuring the basal pinnae. In *B. minganense* this angle averages 90° (40°–150°), and in *B. lunaria,* 150° (100°–190°). The maximum width of the pinnae and lobes of *B. minganense* runs roughly one-third that in leaves of *B. lunaria* which grow with it. The pinna at the mid-point (or first below the mid-point) of the axis of the sterile segment was chosen for measurements, and gave the following values: *B. minganense* average breadth, 4 (1–9) mm.; *B. lunaria,* 11 (6–18) mm.

Carefully pressed specimens show that the lower (or proximal) margins of all except the lowest pinnae are normally ascending (sometimes perpendicular) in relation to the axis of the sterile segment in *B. minganense.* In the well prepared specimens of *B. lunaria,* on the other hand, the lower margins descend, running down at an angle greater than 90° to the segment axis.

The upper pinna margin in *B. minganense* extends from the axis of the sterile segment at an angle about three times as great as the corresponding angle in *B. lunaria.* By measuring this angle of the median pinna in both entities, it was shown that the upper angle of *B. minganense* averages 30° (0°–60°) while in *B. lunaria* the average is 10° (the range from overlapping, i.e., –10°, to 35°).

The structure of the apices of the sterile segments provides one of the

sharpest morphological contrasts. The tip of *B. minganense* is formed by the delicate and gradual reduction in symmetry. The penultimate divisions are usually of the same size as, or slightly smaller than, the ultimate division; and they are generally rounded, obliquely-rhomboidal in outline, and usually range from 1–3 mm. in breadth. The tip of *B. lunaria* is much more

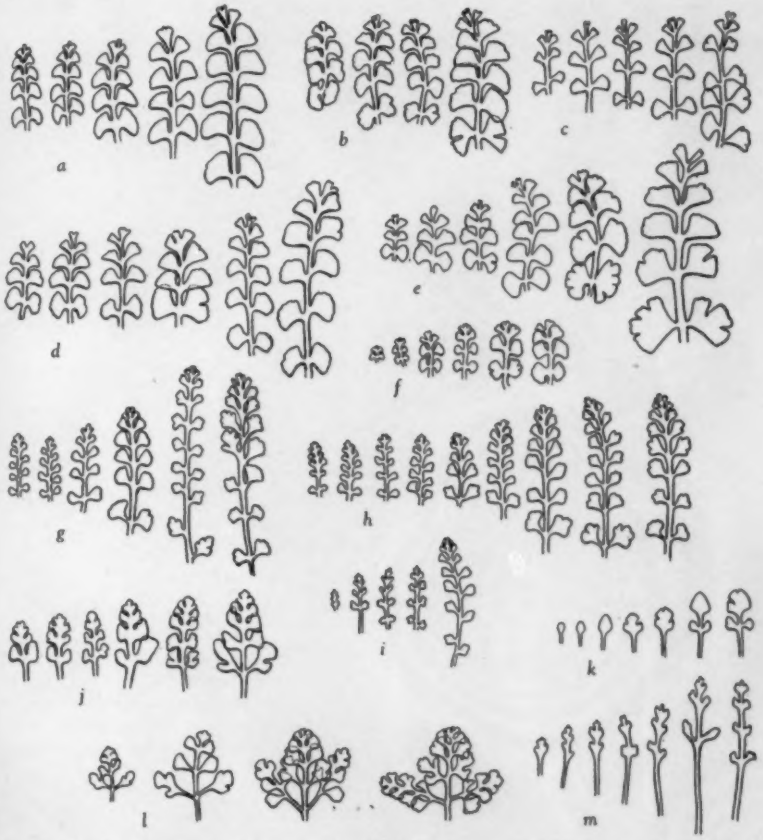

FIG. 1. Sterile segments from various Botrychium populations: a–f. *B. lunaria* and varieties: a. Near Vuorlahti, Finland, *Pl. Finl. Exsicc, 1005* (UC); b. Isle Royale, Mich., *Gillman*, 1873 (NY): c. Shade form, shaded limesink, Bolton, Alpena Co., Mich., *Wagner 8191* (UM); d. Northwest of Cheboygan, Mich., *Wagner 8199* (UM); e. Fiborn Quarry, Mackinac Co., Mich., *Hagenah*, 1954 (UM); f. Small western variety of subspecies, northwest of Jonesville, Butte Co., Calif., *Wagner 4609* (UC). g–i. *B. minganese* and its shade-form. g. Riggsville Corners, Cheboygan Co., Mich., *Wagner 8207* (UM); h. Growing with "d" above, northwest of Cheboygan, Mich., *Wagner 8200* (UM); i. Shade form, near Afton, Cheboygan Co., Mich., *Wagner 8240 and Hagenah* (UM). j–m. *B. simplex* and varieties: j. Bonaventure I., Gaspé Co., Quebec, *Storer 264* (UC); k. Growing with "f" above, northwest of Jonesville, Butte Co., Calif., *Wagner 4610* (UC); l. Var. *compositum*, Cottonwood Lakes, Inyo Co., Calif., *Alexander & Kellogg 3387* (UC); m. Shade form, near Olson, Midland Co., Mich., *Hagenah & Wagner*, 1954 (UM). (All tracings × 2/3).

coarsely and abruptly reduced in symmetry. Its penultimate divisions are generally larger than the ultimate division (the latter being sometimes narrowly linear), and they are more or less sharply cuneate in outline, and from 3–6 mm. in breadth. (In greatly dwarfed individuals of both entities, the same proportional relationships exist in the over-all blade structure, but on a much reduced scale; comparisons must, therefore, be made in relation to whole blades with respect to the entire architecture.)

Several of the more readily measured of the characteristics discussed above have been plotted together in the scatter-diagram in figure 2 to show

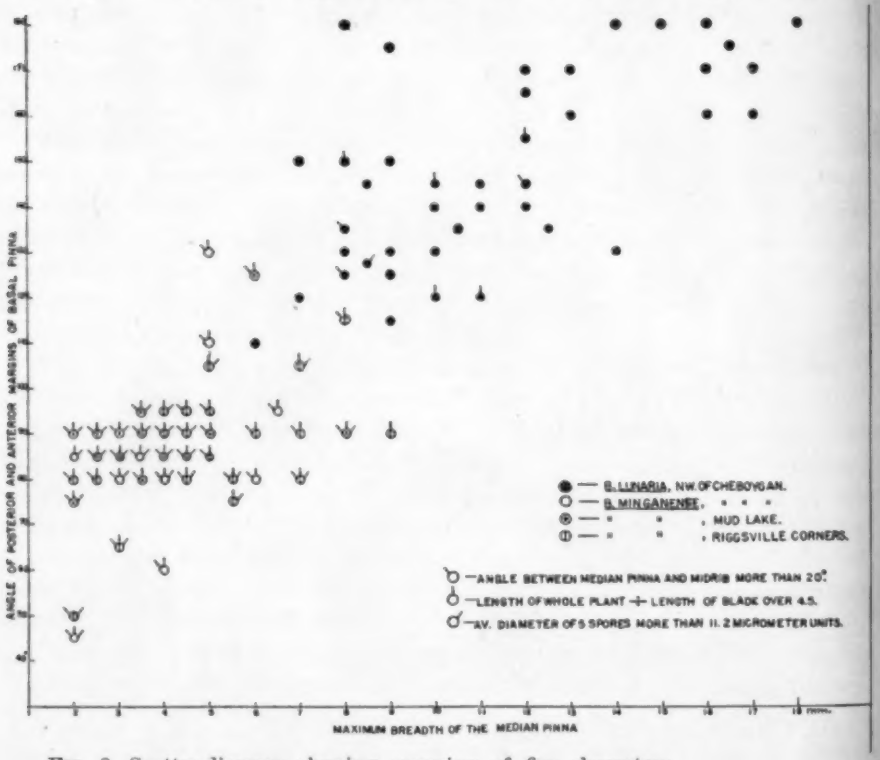
ANGLE OF POSTERIOR AND ANTERIOR MARGINS OF BASAL PINNA
MAXIMUM BREADTH OF THE MEDIAN PINNA
B. LUNARIA, NW. OF CHEBOYGAN.
B. MINGANENSE, " " "
" " , MUD LAKE.
" " , RIGGSVILLE CORNERS.
—ANGLE BETWEEN MEDIAN PINNA AND MIDRIB MORE THAN 20°.
—LENGTH OF WHOLE PLANT ÷ LENGTH OF BLADE OVER 4.5.
—AV. DIAMETER OF 5 SPORES MORE THAN 11.2 MICROMETER UNITS.

FIG. 2. Scatter-diagram showing grouping of five characters.

how consistently they "hold together." The morphological features mentioned below involve the early leaves of the heteroblastic series, late vernation stages, and the structure of the leaf primordia—features which provide valuable contrasts but which require for their study the availability of fairly large populations and observations at different times.

At the time of meiosis in the spring, the unfolding leaves of these two taxa exhibit certain contrasts that become practically lost in pressed material. In *B. minganense* the sterile blades tend to embrace the fertile spike,

a condition which is more or less retained during the summer, as discussed above. At the same time, the sterile blades of *B. lunaria,* although still somewhat folded, are much less so than in the other taxon, and the pinnae

FIG. 3. Late vernation stages of leaves from the mixed population 5 miles S. of Pickford, Chippewa Co., Mich., May 15. Top row: *Botrychium lunaria.* Bottom row: *B. minganense.* (Natural size)

do not clasp the fertile segment except at the base. The fertile segments of unfolding leaves of *B. minganense* generally overtop the blade at a very early stage, but the fertile segment of the other is relatively shorter and remains lower than the sterile until the latter is nearly fully expanded. The orientation of the leaflets and lobes of *B. minganense* is ascending, in *B. lunaria* descending. The contrast in orientation extends also to the branches of the fertile segments (fig. 3, cf. top and bottom rows): in *B. minganense* these branches are directed upward; in *B. lunaria* downward.

The same differences found between adult-type leaves of *B. minganense* and *B. lunaria* extend also, with certain modifications, to the earliest leaves of the heteroblastic series on young rhizomes. Such features as color, segment shape, tip structure, and so on, may be seen on the earliest juvenile-type leaves as well. But they differ prominently in the relative development of their fertile segments: *all* of the youngest juvenile plants of *B. minganense* bear fertile segments, and these generally overtop the sterile segment; *only some* of the youngest plants of *B. lunaria* produce fertile segments at all, and in those which do possess fertile segments, these are overtopped by the sterile segments. These differences are illustrated in figure 4 (materials collected in "mid-season," July 11, 1952, Chippewa Co., Mich.). At this stage, the divisions of the sterile segment in *B. minganense* are hardly cuneate at all, being usually more or less ovate or rounded-oblong in outline; but the comparable juvenile plants of *B. lunaria* already have cuneate or even flabellate segments. The sterile segments in very juvenile (and also the extremely dwarfed) specimens of *B. minganense* are usually over twice as long as broad; but in young (or much dwarfed) examples of *B. lunaria* they are nearly as broad as they are long, and often the sterile segments are wider than they are long, the sterile segment then becoming approximately deltoid in outline. (The last condition is well shown in dwarfed specimens collected by Collins, Fernald, and Pease in 1904, on the summit of Mt. St. Anne, Percé, Gaspé County, Quebec, Gray H.)

As early as 1878, Underwood called attention to the value of leaf primordia in distinguishing the members of *Botrychium*, stressing such aspects as hairiness, orientation of the blade, and position of sterile and fertile segments. The inclusive term "bud" has unfortunately come to be applied in recent years to the single primordium which will become next year's leaf, when in fact the morphological bud of *Botrychium* includes not only the outermost sheath (left by the clasping or encircling base of the previous year's leaf) but also a series of several primordia, telescoped one within the other, these at various ontogenetic stages and differing considerably in appearance. The identificational use of ontogenetic stages in the development of primordia must be regarded carefully, since at least two factors produce variations in them, namely (1) the relative size of the

FIG. 4. Juvenile leaves from the mixed population 5 miles S. of Pickford, Chippewa Co., Mich., July 11. Top row: *Botrychium minganense*. Bottom row: *B. lunaria*. (×1¼).

whole plant, and (2) the relative age of the primordium. Underwood himself recognized (1881) at least one case in which variations from the "norm" occurred. In our study of the primordia under consideration here, we chose to examine the late-season stage of next year's leaf primordium, and we did note considerable variation, although certain differences were decidedly uniform and diagnostic. Collections of 38 whole buds of *B. minganense* from just south of Riggsville Corners, Cheboygan Co., were made in F. A. A. (formalin-acetic-alcohol) killing solution on August 21; and 19 of *B. lunaria* northwest of Cheboygan two days later. Primordia at one stage of development of the latter species have already been figured and described by Underwood (1878). In this study it was found that the buds of the two taxa are markedly distinct: In *B. minganense* the leaflets of the sterile segment are much smaller in relation to the whole structure than in *B. lunaria,* as shown in figure 5. In *B. lunaria,* the leaflets are not only relatively larger, but they tend to surround not only the embryonic fertile segment but they also overlap more or less over the abaxial side of the sterile segment across the midrib. In lateral view, the embryonic pinnae of *B. minganense* extend only half-way across the primordium; of *B. lunaria* the pinnae extend three-fourths or more of the way, generally nearly or quite covering the sterile segment. In abaxial view (i.e., from the sterile segment side), only the basal leaflets of *B. minganense* overlap the rachis; on the contrary, usually at least several of the leaflets of *B. lunaria* overlap the rachis, and they commonly also overlap the leaflets from the opposite side. (Cf. fig 5, a and b with e and f). The apices of sterile segment primordia of *B. minganense* are made up of more segments in comparison with those of corresponding primordia of *B. lunaria.* The apex of the sterile segment of *B. minganense* equals and parallels the fertile segment; that of *B. lunaria* is longer than, and is arched over, the fertile segment.

Cytological distinctness. Victorin (1927) has already shown that the spores of *Botrychium minganense* are larger than those of *B. lunaria.* His averages and ranges, based on many hundreds of measurements, were as follows: *B. minganense* 36.6 (32-40) microns; *B. lunaria,* 29.8 (24-32) microns. Because of his work, we did not attempt to make many measurements of the spores of the living plants with which we were primarily concerned; instead we merely used an ocular micrometer in a 15X eyepiece and a 43X objective, and estimated diameters to the nearest micrometer unit. Only five spores were measured in each case, but the averages showed a clear difference (i.e., less than, or more than, 11.2 micrometer units) in over 80% of the cases (fig. 2). In our subsequent studies of herbarium materials, we have noticed that the spores of *Botrychium* appear to collapse considerably in dried specimens, and there is evident distortion in

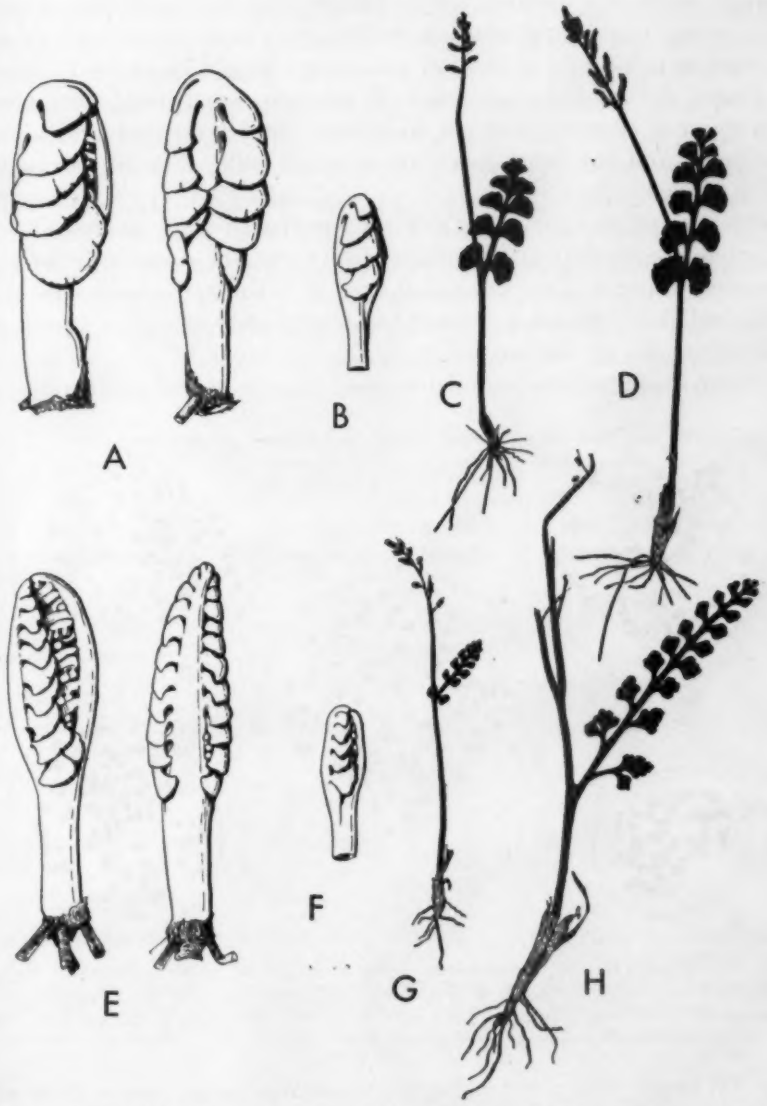

FIG. 5. Leaf primordia and mature plants of moonworts from Cheboygan Co., Michigan. a–d. *Botrychium lunaria.* a, b. Leaf primordia from northwest of Cheboygan, Aug. 23: a. Large-sized specimen, side view (left); abaxial view (right); b. Small specimen. c, d. Whole plants, N.W. of Cheboygan. e–h. *B. minganense.* e, f. Leaf primordia from south of Riggsville Corners, Aug. 21: e. Large-sized specimen, side view (left), abaxial view (right); g, h. Whole plants: g. Approximately average specimen from south of Riggsville Corners. h. Unusually large specimen, 4 miles south of Wolverine. (Primordia ×2; whole plants ×⅓).

the spore walls. We are inclined to believe that for truly precise studies of this genus based on herbarium collections, uniform methods of treatment such as those used in modern palynology should be applied. (In other fern genera, for example *Asplenium, Dryopteris, Cystopteris,* etc., in which the exospore is invested with an additional outer layer, the perispore, the living spore and the dried spore are so much alike that no special treatment is needed.)

With regard to spore size and its correlation with polyploidy, it is interesting to note that in the "least moonwort," *B. simplex,* in which the chromosome number is the same as that in *B. lunaria,* the spores are larger. The diploid *B. simplex* has spores of approximately the same size as those of the tetraploid *B. minganense.*

Chromosome numbers were determined (fig. 6) by the method described

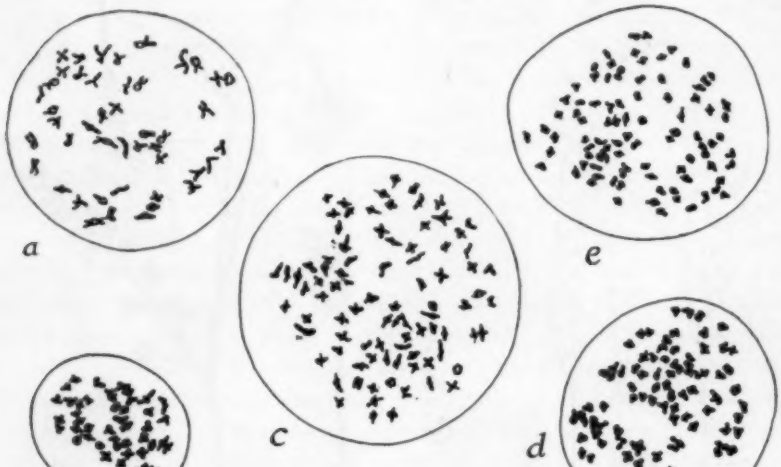

FIG. 6. Chromosomes of Botrychiums from Michigan. a, b. *B. lunaria:* a. Maple R. Dam, Emmet Co.; b. 5 mi. south of Pickford, Chippewa Co. c, d. *B. minganense:* c. 5 miles south of Pickford, Chippewa Co.; d. 4 miles W. of Pellston, Emmet Co. (Shade form). e. *B. matricariaefolium,* Springvale Twp., Emmet Co.

earlier (Wagner 1955), but using aceto-carmine stain rather than aceto-orcein which had too great a tendency to precipitate with this material. The numbers as shown in Table 1 of the two taxa under consideration are different, that of *B. minganense* being $n = 90$, i.e., double that of *B. lunaria* which is $n = 45$. These karyological records for *B. lunaria* are the first from North American populations, and the only previous report in the literature was that by Manton (1950, pp. 269, 270) on typical material from Teesdale, England. Tetraploids based on $x = 45$ are now reported

in four species of *Botrychium* (*B. lanuginosum, B. daucifolium,* Manton & Sledge, 1954 p. 135, *B. matricariaefolium,* and *B. minganense*).

Although the chromosome complement of *B. minganense* is double that of *B. lunaria,* this difference should not be construed alone as a primary basis of species recognition. By themselves the numerous points of morphological difference between the plants, exclusive of chromosome number, should be sufficient, in our opinion, to warrant upholding them as two specifically distinct taxa. However, the chromosome difference does add to the ensemble of distinctions, and, in particular, it points to a genetic isolational barrier between them, as will be discussed below.

Discussion. As summarized in Table 2, there are certainly over a dozen differences between *Botrychium minganense* and *B. lunaria,* and these differences remain when they are found growing side-by-side and inter-

TABLE 2. *Some contrasting features of Botrychium minganense and B. lunaria.*

	B. MINGANENSE	*B. LUNARIA*
1. Color of leaves.	Deep chrysotile green.	Light Cress Green.
2. Blade orientation (living plants).	Sterile segment trough-shaped	Sterile segment flat.
3. Leaf length / Sterile segment length.	4.5 (2.0–8.0)	3.5 (2.0–6.0)
4. Angle between the lower and upper margins of the basal pinna.	90° (40°–150°)	150° (100°–190°)
5. Lower margins of the median pinnae (pressed specimens).	Ascending.	Descending.
6. Breadth of median pinna.	4 (1–9) mm.	11 (6–18) mm.
7. "Axillary" angle of median pinna.	30° (0°–60°)	10° (−10°–35°)
8. Proximity of pinnae and lobes.	Distant.	Approximate.
9. Structure of tip of the sterile segment.	Penultimate divisions small and rounded.	Penultimate divisions coarse and angular.
10. Late vernation stages (living or fixed material).	Branches of fertile segment ascending.	Branches of fertile segment descending.
11. Youngest juvenile leaves.	Fertile segment present, overtopping the sterile.	Fertile segment commonly absent, if present overtopped by the sterile.
12. Oldest leaf primordia.	Pinnae small, not covering the fertile segment or overlapping the midrib of the sterile.	Pinnae large, nearly covering the fertile segment, and overlapping the midrib of the sterile.
	Apex of sterile segment equalling the tip of the fertile segment.	Apex of sterile segment longer, and arching over the tip of the fertile.
13. Spore size.	36.6 (32–40) microns.	29.8 (24–32) microns.
14. Chromosomes.	$n = 90$.	$n = 45$.

mixed in exactly the same habitat. These differences, therefore, must represent genotypic ones. We have not seen evidence that *B. minganense* "passes imperceptibly" into typical *B. lunaria*. Perhaps there is overlap of single characters. But the strong character-complex which in its entirety must be considered the basis for taxonomic interpretation holds together in general and can be depended upon. In the state of Michigan the two taxa appear to be discrete entities, and judging from herbarium collections studied we have seen no reason to suspect that the differences described here do not apply to the populations in other areas. Furthermore, the evidence from karyology indicates that in all probability gradual and complete intergradation between *B. minganense* and *B. lunaria* would be difficult or impossible genetically.

Unfortunately Victorin, in his illustrations (op. cit., figs. 1 and 2, and Pl. 1) and in his description, emphasized the giant and grotesque forms of *B. minganense*, thus giving what seems to us to be a misleading impression. One might just as well select the "overgrown" and bizarre specimens of *B. matricariaefolium* or *B. lunaria*, that occur especially in certain colonies, to form a concept of those species. In Michigan, enlarged and teratological specimens of *B. minganense* are relatively uncommon, and our illustration, figure 5, H, represents an extremely large individual and is not at all typical. Judging from the populations we have studied, individuals more "typical" of what we consider the normal populations of this entity are smaller and more regular in appearance. Victorin's illustration (his Plate 2) from a colony on l'anse au Capelan on Anticosti Island fits far better our generalized concept of a population of this species (in spite of the statement that "Cette colonie était remarquable par l'absence totale d'anomalies"). The variability of *B. minganense* in the populations we have examined is not nearly so great as that of *B. matricariaefolium*. However, the most variable species of *Eubotrychium* in North America is evidently *B. simplex*, some forms of which have been, in fact, repeatedly confused with other species in herbaria (cf. fig. 1, j, k, l, and m).

Within the practically cosmopolitan species, *B. lunaria*, a very large number of genetically different strains must exist. However, it seems to be true that the plant which in North America has been called "f. *onondagense*" and which Fernald has (probably correctly) referred to "f. *gracile*," is a purely ecological growth-form, entirely without genetic significance. The deep-shade form of *B. lunaria* differs from the ordinary form only with respect to the attenuation of the leaf and consequently apparent reduction in the amount of relative lamination associated with less light. Accordingly, mainly characters #4 through #8 in our enumeration in Table 2 are effected, and may approach the corresponding measurements of typical *B. minganense* grown in habitats of normal insolation.

In other words, the deep-shade form of *B. lunaria* comes to resemble in certain respects the normal form of *B. minganense*. However, the deep-shade form of *B. minganense* is entirely different from the deep-shade form of *B. lunaria* (cf., fig. 1, c and i).

The California plant (fig. 1, f) which we originally referred to taxon *minganense*, and which has been so identified repeatedly in herbaria, appears now to be much more closely related to true *B. lunaria* and may represent a subspecies of the latter. The California plant which we studied in the field agrees with *B. minganense* in its yellowish color, but there the resemblance essentially stops: it differs from *B, minganense* but agrees with *B. lunaria* in the wide angle between the margins of the pinnae, the descending lower margins of the pinnae, the smaller angle formed by the inner margin with the midrib of the sterile segment, the coarse and angular penultimate and ultimate divisions of the segment tip, and in other features. From typical *B. lunaria* it differs in the aforementioned yellowish color and in its small size, being generally only half or less the stature of eastern and northern North American, and European, plants. The California plants from Butte Meadows are quite closely matched with respect to stature and cutting, however, by individual specimens on a sheet of four collections in the Gray Herbarium from Quebec—all of them more or less dwarfed in comparison with the average eastern North American plant (Bic, Rimouski Co., *Collins & Fernald,* 1904; Percé, Gaspé Co., *Collins, Fernald, & Pease*, 1904; and Carleton, Bonaventure Co., *C. & F.*, 1904). The Quebec specimens on the other hand however, do not show the yellowish color as well as this can be determined. A sheet in the New York Botanical Gardens taken in White Pine Co., Nevada by Bassett Maquire (*no. 21183*) has plants which are apparently transitional between the Californian and the typical varieties.

So far as we have determined, true *B. minganense* does not occur in California. Our records for *B. minganense* include localities in Labrador, Quebec, Ontario, Vermont, New York, Michigan, Wisconsin, Utah, Idaho, Montana, Alberta, British Columbia, and Alaska. In the west, *B. lunaria* or the California variety of it occurs in Idaho, Montana, Wyoming, Arizona, Colorado, Utah, Nevada, California, Washington, Alberta, British Columbia, Yukon, Alaska, and the Aleutians.

It would not be surprising if the California populations of *B. lunaria* proved upon the amassing of larger and better collections to represent a distinct subspecies. Striking differences within various species of grapeferns in North America exist between east and west, as illustrated by comparing the *botrychia* of Quebec and New York, for example, with those of Utah and California: in the west, *B. simplex* is represented in large part by extremely striking populations, var. *compositum* (Lasche) Milde, as exempli-

fied in figure 1, 1; but such populations are either very rare or absent entirely in the east. *B. matricariaefolium* in the west occurs as its subspecies *hesperium* Maxon and Clausen. *B. lanceolatum* appears in the west as its typical form, and in the east as subspecies *angustisegmentum* (Pease & Moore) Clausen. The gigantic leaves of some of the western populations of subspecies *coulteri* (Underw.) Clausen, and *californicum* (Underw.) Clausen, are not matched in eastern populations of other subspecies of *B. multifidum*. The far western plant which we consider to belong to *B. lunaria* seems to differ especially in the small stature, but there is nothing manifest in the habitat that would seem to limit its growth there, particularly in view of the fact that it is accompanied by other *botrychia* of normal stature for those species. The combination of this small size with a tendency toward yellowish coloration appears from present information to be the primary distinction of the western entity from typical *B. lunaria*. Careful morphological and cytological comparisons should be initiated to determine the status of the western plant.

The final point to be discussed here is that of the relationships of *B. minganense*. In all likelihood, *B. minganense* should be placed in proximity to *B. lunaria* and *B. simplex*, the two species to which it seems to have the greatest number of resemblances, and with which it seems most often to have been confused in herbaria. On the other hand, the possibility does exist that *B. minganense* being a polyploid, could have arisen as a species hybrid. In certain respects, for example, *B. minganense* suggests *B. matricariaefolium*, and the possibility that *B. minganense* might have originated as a hybrid of *B. lunaria* and that species was once entertained (Wagner 1955). However, with our now clearer concept of *B. minganense*, and with the knowledge that *B. matricariaefolium* in a number of populations (2 new reports listed in Table 1) has the same number of chromosomes as *B. minganense*, the possibility of this origin seems considerably less tenable. Another hypothesis, namely *B. lunaria* X *B. simplex* seems equally unlikely. Consequently, in conclusion, we feel led to regard *B. minganense* as a normal species, although polyploid in chromosome number. It is a species that is apparently endemic to parts of North America and it seems to be just as distinct from *B. lunaria* as other species in this immediate circle of affinity.

SUMMARY

1. *Botrychium minganense* Victorin (Ophioglossaceae) was described in 1927. It was subsequently reduced to the status of a variety, and then a form, of the nearly cosmopolitan *B. lunaria* (L.) Sw. Plants from California as well as numerous localities in northern North America were referred to taxon *minganense*. An attempt is made here to evaluate the distinctness of

B. minganense and *B. lunaria* in localities where the two occur together in Michigan.

2. Part of the problem of discriminating critical species in this group arises from the need of good population samples and adequate specimens. A number of localities found for the two taxa under consideration here in northern Michigan made it possible to evaluate their distinctness on the basis of numerous living specimens and carefully preserved specimens.

3. The morphological distinctions between *B. minganense* and *B. lunaria* are shown to include differences in the laminar color, the orientation of the sterile blades, the relative lengths of sterile blades, the angles between the lower and upper margins of the basal pinnae, the orientation of the lower margins of the pinnae, the breadth of the pinnae, the structure of the tip of the sterile segment, as well as the late vernation stages, the juvenile leaf structure, and the form of the leaf primordium. These differences are discussed in some detail and illustrated in certain cases.

4. Both of the taxa possess marked forms of deep-shade habitats which differ considerably from one another. However, the shade form of *B. lunaria* (*B. l.* f. *onondagense* (Underw.) Butters & Abbe) may tend to resemble typical plants of *B. minganense* of normal habitat in certain designated respects.

5. Cytologically, *B. minganense* differs from *B. lunaria* in having spores of larger size, and in having $n = 90$ chromosomes rather than $n = 45$. Although not necessarily a primary basis of species distinction, the latter difference in chromosomes indicates that the two taxa are probably reproductively isolated.

6. The California plant which has been identified as *B. minganense* does not represent that taxon but rather a variety or subspecies of *B. lunaria*. It shares most of its characteristics with the latter species, differing from it primarily in its laminar coloration and in its stature.

7. *Botrychium minganense* does not appear on present evidence to have had hybrid origin. On the contrary, this taxon is evidently a normal species, endemic to northern North America, and belonging to the general circle of affinity that includes *B. lunaria* and *B. simplex*.

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THE SARMENTOGENIFEROUS VARIETY OF STROPHANTHUS SARMENTOSUS

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In a broad and strictly taxonomic sense, *Strophanthus sarmentosus* P. DC. is best considered merely as a polymorphic species, warranting little attention to the various forms. However, one of the chemically distinct variants has assumed sufficient importance in chemical literature to justify a formal name, at least for the sake of convenience. Since this chemical type is supported by some morphological characters and geographical distinction, a varietal place in taxonomy is proposed for it. The seed yields a high percentage of sarmentogenin, a compound preëminently suited for conversion to cortisone. The fruit is slender, tapering and thin-walled. Both the fruit structure and the seed chemistry are hereditary. The trinomial herewith proposed has already appeared in literature but needs reference to a basonym for botanical validity.

Strophanthus sarmentosus var. **senegambiae** (A. DC.) Monachino, stat. nov.

S. Senegambiae A. DC., Prodr. **8**: 418. 1844.

S. sarmentosus forma *senegambiae* (A. DC.) Chevalier, Rev. Int. Bot. Appl. **30** (327–328): 7, sub. pl. 2, fig. D. 1950.—without basonym.

"*Strophanthus* spec. var. *sarmentogenifera* No MPD 50" Euw, Reber & Reichstein, Helv. Chim. Acta **34** (2): 413. 1951.

"*Strophanthus* spec. var. *sarmentogenifera* Nr. BSAK 11247" loc. cit. 415.

"*S. sarmentosus*, savannah form" Callow, Meikle & Taylor, Chem. & Industry **70**: 336–337. 1951.

"*S. sarmentosus* var. *senegambiae* (A. DC.) Monachino" ex Heftmann, Berner, Hayden, Miller & Mosettig, Arch. Biochem. & Biophysics **51** (2): 336. 1954.—without basonym.

S. sarmentosus var. senegambiae is chiefly a chemical variety confined to the savanna areas in the northern range of the species. The seeds yield 0.1 – 1.0 + per cent sarmentocymarin, whereas *S. sarmentosus* var. *sarmentosus* and other varieties yield less than 0.02 per cent or an undetectable amount. When only a few seeds are available, the variety can be identified by paper-chromatographic study. The fruits are usually more slender than those of the other varieties, with tapering apex and much thinner, often

[1] The author wishes to acknowledge his indebtedness to Prof. T. Reichstein, Organisch-chemische Anstalt der Universitat, Basel, Switzerland, for furnishing large series of follicles of *Strophanthus sarmentosus* correlated with chemical analyses.

lightly lenticelled pericarp; the seeds are very bitter and generally smaller than those of the forest varieties. The fruit-walls are 2–3 (–4) mm. thick, while those of other varieties are typically more than 3 mm., up to 11 mm. thick. References to morphological differences between the savanna (var. *senegambiae*) and the forest varieties have already appeared in literature. Meikle (1950), Callow, Meikle & Taylor (1951) noted that in the savanna type the leaves and flowers are smaller, the follicle more pointed and smaller, the seeds slimmer and more grey hairy than those of the forest form. Bush and Taylor (1952) stated that the seeds of the two forms, the savanna and forest types, have a fairly characteristic appearance to the practiced eye. The morphological characters of the variety, however, are very weakly defined and not absolutely reliable. In some instances, the fruit shape and size of other varieties are similar to those of *S. sarmentosus* var. *senegambiae*. The flower and leaf size are even less reliable. The geographical range is not strictly exclusive; non-sarmentogeniferous varieties are rarely found in the range of var. *senegambiae*.

Seeds of the different varieties of *S. sarmentosus* have been sent to Heber W. Youngken for study to ascertain whether some histological, cytological or microchemical test will lend itself to separating those containing sarmentocymarin. In a preliminary examination in 1950, he found Jacobs-Munch's classic seeds, which were used for the original isolation of sarmentogenin in 1929, "not identical" with seeds of *S. sarmentosus* var. *major* Dewèvre collected by Father Callens in the Belgian Congo. The following is Professor Youngken's description of seeds of the var. *senegambiae* from French Sudan, K. S. 51–22: "Seeds dark brown, ovate-lanceolate to lanceolate, up to 12 mm. in length and 3 mm. in width; epidermal hairs of seed coat yellow, up to 561μ in length and 11.9μ in width at base; epidermal cells of seed coat in surface view elliptic, triangular, to irregularly quadrangular and rectangular, up to 114μ in length and 49μ in width, their anticlinal long walls wavy and anticlinal end walls straight or curved and up to 12μ in thickness; cotyledons slightly unequal as seen in median cross sections; rosette aggregate crystals up to 15μ in diameter are present in the cotyledons."

The type of *S. senegambiae* was cited in Prodromus: "in Senegambiâ (Heudelot!) . . . v. in h. Boiss." Dr. C. Baehni asked Dr. Weibel to examine the type in the Boissier Herbarium and reported that it is labeled "Senegal. Heudelot 1828", without number. It was named *S. sarmentosus* by Gilg in 1901. I have seen Heudelot material from Senegal preserved at Geneva and elsewhere, but not the Boissier type. According to Dr. Baehni, the type and the Geneva Heudelot specimen I examined seem to be identical and are labeled in the same handwriting. The type has two or three leaves at the top of the twig, while the specimen examined by me is without leaves. There are no fruits in any of these collections.

The sarmentogeniferous variety grows generally in laterite or granite soil, in savanna and thorn bush, from Senegal to Lake Chad and southward to about latitude 12° or 13° north of the equator. It has been collected in Senegal, Gambia, Northern French Guinea, French Sudan and Northern Nigeria. Maps indicating collections of *S. sarmentosus* var. *senegambiae* and other chemical varieties of the species appear in Schnell, Euw, Richter & Reichstein (1953). Another map showing where seeds of the "savannah" (var. *senegambiae*) and the "forest" types were collected in Nigeria is presented by Bush and Taylor (1952). The ecological and microclimatic setting of *S. sarmentosus* in the region of Kita, where the sarmentogeniferous variety grows, was investigated by Paul Jaeger in the wet and dry seasons of 1951. He reported that the plant is particularly fond of arid places, although tolerant of forest galleries, margins of rivulets and humid shady ravines. He saw the following trees, lianas and herbs associated with it: *Bombax angulicarpum, Combretum micranthum, Manilkara multinervis, Pterocarpus lucens, Tricalysia coffeoides, Ximenia americana, Abrus precatorius, Combretum tomentosum, Cissus quadrangularis, Sansevieria, Tacca involucrata.*

Illustrations of *S. sarmentosus* var. *senegambiae* have already been published: Photo of MPD 50, fruits and flowering branches (Monachino 1953a); fruits and seeds (Schnell et al. 1953); seeds (Euw et al. 1951). Figures of leaves, flowers, fruit and seed of collection from Les Nyayes, Senegal (Chevalier 1950). Photo of pericarps of K. S. 51–20, K. S. 51–22 and K. S. 51–27 (Richter et al. 1953). Photo of seeds from sample used by Jacobs and Heidelberger in their original isolation of sarmentogenin (Monachino 1950b). The following three photos are also possibly of var. *senegambiae*: Flowering plant and unripe pod, from Zaria, North Nigeria (Callow 1950); flowers (Meikle 1950); fruiting plant in Gambia (Fairchild, Exploring for Plants, p. 472. 1930).

There has accumulated a large amount of literature on sarmentogenin or sarmentocymarin. Some of the principal works from the chemico-botanical point of view are cited in this paper, and other bibliographical references appear therein. The description of fruits, chemistry of seeds, chemical varieties of *S. sarmentosus* and tables of specimens collected are presented by Schnell, Euw, Richter and Reichstein (1953); description of fruits, by Monachino (1953a); chemical varieties of *S. sarmentosus,* by Schnell, Euw, Richter and Reichstein (1953). The historical background of sarmentogenin can be had in Buzas, Euw and Reichstein (1950), Euw, Katz, Schmutz and Reichstein (1949), Monachino (1950a and b).

It is generally known that chemically distinct strains of the same species of plants often display little or no perceptible botanical difference. In *Strophanthus,* chemico-botanical incongruity has been shown not only in *S. sarmentosus* but also in *S. Welwitchii* (Helv. Chim. Acta. **35**: 152–160.

1952). Four chemical variants have been involved in *S. sarmentosus*. Variety *senegambiae* is not wholly homogenous chemically (Schindler & Reichstein 1951); it comprises various strains having a variable percentage of sarmentogenin. At least three or four chemically "mixed forms" of *S. sarmentosus* have been studied from Liberia, French Guinea and the Ivory Coast. Sarmentocymarin is found in several other species of *Strophanthus, S. Gerrardii, S. Courmonti* and *S. Petersianus* (Helv. Chim. Acta **33**: 522–529, 1006–1013 & 1551–1566. 1950) and possibly in *S. intermedius* and *S. amboensis* (Heftmann, Berner, Hayden, Miller & Mosettig 1954).

The fruit structure is the best morphological character for distinguishing *S. sarmentosus* var. *senegambiae*. Seeds of high sarmentogenin content have been found exclusively in thin-walled fruits, never in thick-walled ones. The concurrence is not strictly reciprocal, unfortunately, for in rare instances seeds from thin-walled follicles have yielded sarverogenin or practically no glycosides. Plants with thin pericarps (thickness 3–4 mm. and 2–2.5 mm.) similar to those of the sarmentogeniferous variety but containing only small amounts of sarmentogenin (yielding about 0.5% sarmudoside instead) have been found growing in French Sudan, near Kita and Kayes (Richter, Mohr & Reichstein 1953), in the range and habitat of var. *senegambiae*. Two collections (follicle-walls 2.5–3 mm. thick) of the southern chemical variety, yielding .05%–.2% sarveroside, .1%–.4% panstroside and ca. .5% sarmentoside, have been made near Dakar, Senegal, the type locality of MPD 50. The shape and sizes of the fruits of some plants in French Guinea are similar to those from Senegal, while others are like those of *S. sarmentosus* var. *major*. Morphological forms are not always associated with chemical differences in the seeds; for example, seeds from the variants described by Schnell (1950) were reported by Reichstein to have practically no chemical differences. The follicles of *S. sarmentosus* var. *major*, from the Belgian Congo, contrast strongly with those of var. *senegambiae;* they are very stout, blunt tipped, thick-walled and densely lenticelled. Those of the Sierra Leone variety are somewhat intermediate. Illustrations of the fruits of these varieties can be seen in Schnell, Euw, Richter & Reichstein (1953). The mericarp photographed by Younken (Jour. Am. Pharm. Ass., Sci., Ed. **39**: 617. 1950) represents var. *major*. Photos of the pericarp of a variety growing with var. *senegambiae* but devoid of sarmentogenin can be seen in Richter, Mohr & Reichstein (1953).

Actual cultivation experiments have demonstrated that the seed chemistry and fruit structure of *S. sarmentosus* var. *senegambiae* are hereditary. Seeds of MPD 50, originally collected in the vicinity of Dakar and found to have .36% sarmentocymarin and .1% sarnovide, were sown in Surinam in the latter part of 1950. The first flowers appeared in November, 1952, and the first ripe fruit was collected in October, 1953, when the plant reached a height of four meters. The fruit had a thin wall and was shaped

like that of the original parent plant. The single fruit contained ten grams of seeds, which upon analysis in the Reichstein laboratory gave .47% pure sarmentocymarin and .11% pure sarnovide. Another seed sample of MPD 50 was sown in the vicinity of Man, Ivory Coast, about August, 1950, and flowered in the summer of 1952. Seeds from the cultivated progeny (120 grams) were found to have a chemical composition approximating that of the original seeds. Sarmentocymarin has never been isolated from seeds of wild plants growing in the vicinity of Man. Corroborating results were obtained with other seeds of var. *senegambiae* grown in Curaçao and Sumatra. The first ripe fruits were obtained about three years after sowing. In all cases, the glycosides were the same as in the original seed material, although the percentage varied, being higher in plants grown in dry hot climates. As early as 1951, Callow, Meikle & Taylor had stated that plants from seeds of the forest and savanna kinds germinated at Kew have retained the larger or smaller leaf of the parent plants.

In its natural habitat, in a sunny exposure, a single vine of *S. sarmentosus* var. *senegambiae* has been observed to have up to one-hundred or more fruits; it can average about 500 grams of pure seed per year. On the other hand, the plant does not set fruit well in cultivation. Tests with H. G. 36 by the Boyce Thompson Institute for Plant Research, Yonkers, N. Y., have demonstrated that the seeds germinate readily in both acid and lime soils; up to 90% germination was obtained. M. J. Dijkman reported that cultural experiments were carried out with seedlings of MPD 50 in Florida and will be published later.

Seeds of *S. sarmentosus* var. *senegambiae*, obtained from Professor Reichstein, have been distributed by the New York Botanical Garden since December, 1951, for trial planting in Florida, Louisiana, California, Puerto Rico, Costa Rica, Peru, Hawaii (Kauai, Oahu, Maui and Hawaii) and Java. The following are some of the cultivated numbers of the sarmentogeniferous variety: *H. G. 51-13* (seeds from probably a single plant; road Dolafine to Koussan, ca. 8 km. south of Koussan, ca. 12° 13′ long., 14° lat., French Senegal; sparse dry forset bordering on laterite desert, well exposed, ca. 200 m. alt.; April, 1951). *H. G. 51-36* (seeds from many plants; Mbacké-Boby, ca. 15° 50′ long., 14° 45′ lat., Senegal; said to be growing mostly on sandy and stony loam along dried-out water course, well exposed, 50–100 m. alt.; 1951). *H. G. 43* (seeds from a group of plants; vicinity of Dakar, Senegal; April, 1951). *K. S. 51-22* (seeds from a single plant; between Bafoulabe and Kita, French Sudan; about 200 m. alt.; April 19, 1951). *K. S. 51-31* (seeds from a single plant, liana about 30 years old, ca. 4 m. high, spreading 10 m., about 20 fruits, seeds from 12; near Thiès-MBour, ca. 16° 55′ long., 14° 40′ lat., Sengal; dry laterite in slight depression, western exposure, vegetation in vicinity dense dry forest and thorny bush, 40% relative humidity at 40° Celsius, 14.45 o'clock, 100 m. alt.; May 4,

1951). *K. S. 51-53* (seeds from bush about 10 years old, 3 m. high, spreading 1.5 m., in full bloom, carrying 7½ ripe fruit; about 112.8 km. north of Thiès on the way from Louga to Kébémèr, Senegal; vicinity of cultivated soil, pastures, a few trees, shrubs and hedges, 90% relative humidity at 20° Celsius, 11.15 o'clock, 30 m. alt.; May 29, 1951). *MPD 50* (seeds from many plants; vicinity of Dakar, Senegal; March–April, 1950).

A review of the species and varieties which may be involved in treating *S. sarmentosus* has already been presented (Monachino 1953b). Since the type of *S. senegambiae* lacks fruit, its chemical identity is based on supposition, supported principally by geographic considerations. *S. senegambiae, S. sarmentosus* and the very different *S. hispidus* are the only species that have been collected in the range of the sarmentogeniferous variety. Gilg, in his monograph of the genus, suggested that the type of *S. laurifolius* P. DC., which he examined and identified as *S. sarmentosus* in 1901, may have been collected in Senegambia by Sparmann. There is no report, however, that Sparmann ever collected in Tropical West Africa. According to R. D. Meikle at Kew, De Candolle, in his 1804 monograph, p. 6, said of *S. laurifolius*: "in Africa australi Reperit Cel. viator Sparrman." The type was examined by Dr. Weibel at Geneva, who reports that the original label reads, "Echites caudata L. Sparman." There is no evidence of a Senegal origin of the type material. *Echites caudata* is an oriental species of Strophanthus.

The soundness of the nomenclature adapted in the present paper hinges on still another supposition, that *S. sarmentosus* var. *sarmentosus* is the none-sarmentogeniferous or forest variety. The type was collected by Smeathmann in Sierra Leone, I have seen an authenticated representative deposited in the Delessert Herbarium at Paris. It consists of flowering material, without leaves. F. C. Deighton, Department of Agriculture, Sierra Leone, in answer to my inquiry, wrote as follows: "Smeathmann collected in Sierra Leone in the 1770's and 1780's mostly in the Banana Islands. At that time, it would have been impossible for Smeathmann or anyone else to penetrate further inland than a few miles from the coast, except along the creeks and rivers insofar as they are navigable from the sea (in most cases 10–20 miles). The chief collecting grounds would therefore be the Colony Peninsula, around Freetown in particular, Sherbro Island (northern shore; mainly mangrove swamp) and the neighbouring creeks, and the Bullom shore opposite to, and north of, Freetown, perhaps traveling up the Scarcies rivers in the north-west of Sierra Leone, near the French Guinea border. Most of the collecting area available would thus be forest, but on and around the lateritic pan areas in the Colony Peninsula there is a *Parkia biglobosa* scrub and grass vegetation resembling savannah, and on the Bullom shore (sandy soil with lateritic pan areas)

there are large areas of *Lophira alata-Parkia* orchard bush savannah and scrub. Rainfall is, of course, 120–250 inches a year over all this area. Smeathmann may thus have collected *S. sarmentosus* from the scrub savannah or true forest. The plant is common, and I should think the odds are that he got it from a cleared forest area." According to Dr. Deighton, the follicles of *S. sarmentosus* from the vicinity of Njala are 9–10 cm. in circumference at the widest part, and the walls vary from 5–10 mm. in thickness. A large sample of seeds was collected by him about May, 1950, mostly from riverain forest in the vicinity of Njala, and portions from the same lot were sent to Merck & Company in the United States and to the Medical Research Council in Great Britain. The Merck material was analyzed by Reichstein's team and found to be the variety poor in glycosides. Much earlier, in 1929, Jacobs and Heidelberger (Jour. Biol. Chem. **81**: 765) had tested a sample of seeds of *S. sarmentosus* obtained from the Lands and Forests Department at Freetown, Sierra Leone, and found only traces of bitter glycosides too small for study.

Bush and Taylor (1952) reported that a large sample of *S. sarmentosus* seed from Sierra Leone proved to be the Nigerian "savannah" type, but this report was erroneous, as subsequently admitted. Reference to the same sample was made by Callow, Meikle & Taylor (1951). The seeds tested by Bush and Taylor were from the identical 1950 Najala batch found poor in glycosides by Reichstein. A small amount of seeds, also from the same sample, was sent by the New York Botanical Garden to Dr. Taylor, who identified them as the forest form. A fresh sample of *S. sarmentosus* fruits from the riverain forest near Njala (Kori), the area from which came the seeds sent to Merck & Company and to the Medical Research Council of Great Britain, was dispatched to Reichstein by Deighton in 1954. Three fruit types were represented in the collection; 500 grams of seeds, obtained from 43 mericarps most approximating in shape and wall-thickness the Senegal variety, were analyzed by Reichstein and again found to be the variety poor in glycosides, similar to other samples from Sierra Leone, Liberia, the western part of the Ivory Coast and French Guinea and quite different from those of Senegal, Northern French Sudan and Northern Nigeria.

Since seeds are lacking in the types of *S. senegambiae* and *S. sarmentosus*, and thus cannot be checked by direct chemical analysis, the choice of basonym that has been made here for the sarmentogeniferous variety is based on probability only, not certainty. As an alternative, a new varietal epithet might have been created for a chemically certified type, such as MPD 50; but then note should have been made of its probable synonymy with *S. senegambiae* and *S. sarmentosus* form *senegambiae*.

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A LIQUID MOLD TECHNIC FOR RADIOGRAPHING SURFACES OF LEAVES

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It is the purpose of this article to describe a technic by means of which liquid molds are employed in making radiographs of the topography of one or both surfaces of a leaf.

Vegetable matter, such as a leaf, is very radiolucent[2] and can be radiographed best at voltages of 25 Kv. or lower, well below the range of most dental and medical x-ray machines. The resulting conventional radiograph is a picture produced by the differential absorption of the x-ray beam by the various internal and external parts of the leaf. A topographic radiograph, however, records only the elevations and depressions that occur on the exterior surfaces of the leaf.

When a small quantity of a radiopaque[3] liquid (i.e. saturated solution of zinc bromide) is poured onto a horizontal surface, the liquid spreads out into a layer of uniform thickness. If this layer of liquid is radiographed, a uniformly gray image results. However, if a bubble of air or some other radiolucent material were contained in the radiopaque layer of liquid at the time of the exposure, a dense image of the bubble of air would record. The presence of the radiolucent object at a given location in the liquid causes a reduction in amount of the radiopaque liquid at that location and it is the lesser amount or absence of radiopaque liquid that permits the recording of various densities in the radiograph.

This concept of displacement of the radiopaque liquid[4] by a leaf is illustrated in the diagram presented as figure 1. A small quantity of radiopaque liquid is deposited on a thin sheet of cellulose acetate or other thin radiolucent sheeting. A leaf is placed on this small pool of liquid and then more radiopaque liquid is placed on top of the leaf. A second thin sheet of cellulose acetate is placed over the second quantity of liquid. This completed "sandwich" is placed on a radiographic film and the x-ray beam is directed perpendicularly to the plane of the film. The thin layer of liquid that is trapped between one side of the leaf and an acetate sheet forms a faithful radiopaque mold of the surface of the leaf on one side and of the

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[2] Radiolucent: the property of being relatively transparent to x-ray radiation.

[3] Radiopaque: the property of being relatively opaque to x-ray radiation.

[4] Richards, A. G. Methods for radiographing replicas and molds of surfaces. Med. Radiog. and Photog., 31 (No. 1): 1956.

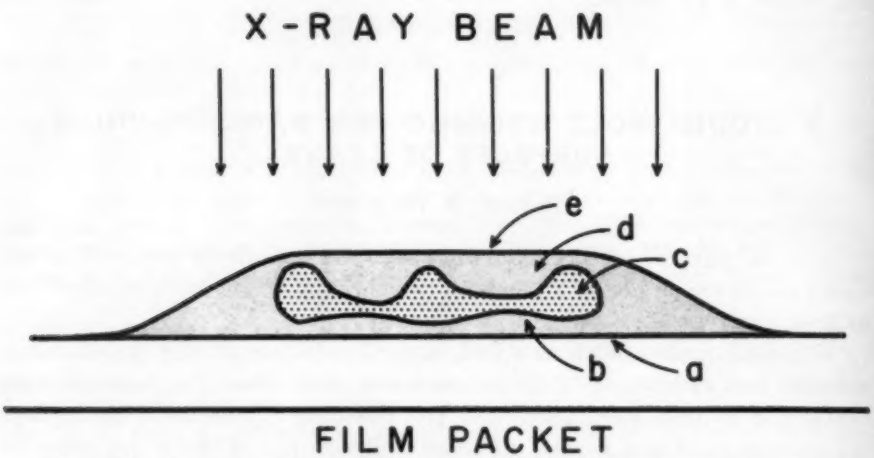

FIG. 1. Diagram illustrating in cross-section how molds in radiopaque liquid are formed of both upper and underneath surfaces of a leaf. The leaf (c) is located between layers of radiopaque liquid (b and d) which are bounded by thin sheets of radiolucent plastic (a and e). The x-rays are directed through the plastic sheets, the molds in radiopaque liquid, and the leaf to form an image of the radiopaque molds on the film packet below.

flat surface of the plastic sheet on the other side. It is the variations in the thickness of the mold in radiopaque liquid, and not the leaf itself, that causes the differential absorption of the x-ray beam to form the image in the radiographic film.

If a mold in radiopaque liquid is formed on each side of the leaf, as indicated in figure 1, the topography of both sides of the leaf will appear superimposed in the radiograph (figure 2, left). When the topography of

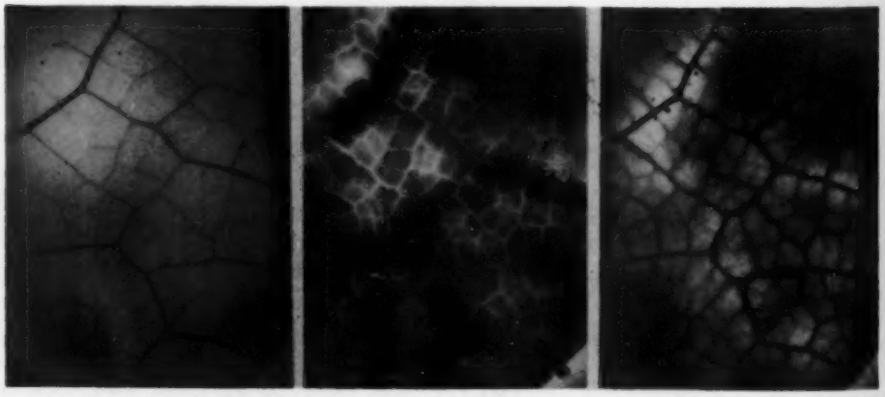

FIG. 2. Topographic radiograms of a portion of a grape leaf. Left: topography of both surfaces (8-second exposure). Center: topography of upper surface (4-second exposure). Right: topography of underneath surface (6-second exposure).

Technical factors: Saturated solution of zinc bromide; 40 KVP; 6 Ma.; 9-inch target-film distance; intermediate-speed dental film-packets.

only one surface is desired (figure 2, center and right), measures must be taken to prevent the radiopaque liquid from forming a mold of the undesired surface.

Sometimes it was found impractical to use a sheet of cellulose acetate to form the smooth side of the liquid mold when the topography of the leaf was very irregular. Under these conditions a small toy balloon was partially inflated with air and pressed against the surface of the leaf under examination. The balloon was held in place by the cone of the x-ray machine contacting the top of the balloon. The contact also ensured that pressure was exerted uniformly on the specimen.

Radiopaque liquids are slowly absorbed by vegetable matter, so all experiments with leaves must be completed with reasonable haste.

It was found that the addition of a wetting agent to the radiopaque solution helped to form accurate liquid molds that were relatively free of artifacts caused by air bubbles.

The equipment and materials that are required for this technic are common and readily available. The type of x-ray machine that is found in nearly every dental office is well-suited for this work. Facilities for the processing of films are necessary also and, again, the dental office provides this equipment. The necessary supplies consist of dental film-packets, thin sheets of plastic, small toy balloons and a small quantity of a saturated solution of zinc bromide (447 grams $ZnBr_2$ dissolved in 100 grams of water). This solution is not expensive and can be obtained from a druggist or chemist.

SUMMARY

1. A method has been described which produces molds of external surfaces of leaves in a solution that is relatively opaque to x-ray radiation. These liquid molds are radiographed by using dental x-ray equipment and supplies to record the topography of the surfaces of leaves.

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UNRECORDED HOSTS AND SPECIES OF PHYSODERMA

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Physoderma is the second largest genus of the chytrids and includes at present almost eighty species, most of which are incompletely known. All are parasites of higher plants, and like terrestrial species of *Synchytrium* many of them induce marked local reactions in their hosts. Such reactions frequently result in the development of galls which may be superficially similar to those caused by species of *Synchytrium*. Probably for this reason, many collectors and mycologists who are not familiar with the differences between the two genera have labeled some of their specimens *Synchytrium* which are in reality species of *Physoderma*. This became evident to me while studying the species of *Synchytrium* which are deposited in herbaria in the United States and elsewhere. Several unrecorded hosts and species of *Physoderma* were found in these collections, and the present brief paper is a report on such species as well as on other undescribed ones which have been received from collectors. It is presented primarily with the object of calling the attention of students of *Physoderma* to the existence of these species.

So far only the endobiotic phase of these species has been observed, and it is not certain that they are new. Additional investigation of living material as well as extensive host range studies must be made before the identities of these species can be determined. Therefore, it is not worthwhile at this time to give them names which may prove to be synonyms. The fact that they occur on different and unrecorded hosts is not sufficient reason, in my opinion, for establishing them as new species. Without doubt, as the genus is studied more intensively many more specimens of *Physoderma* will be found on new hosts, and if the present tendency of creating a new species for each host is followed the genus will soon become unwieldy.

Physoderma on Ligusticum grayi. This fungus was collected by W. N. Suksdorf on Mt. Adams, Washington, Sept. 17, 1894, and sent to Ellis who named it *Synchytrium ligusticii*, according to Cash (1954). Up to the present time it has been listed under this binomial, but examination of type material at the State College of Washington has shown it to be a species of *Physoderma*. It induces numerous conspicuous galls on both surfaces of the leaves and on the petioles and stems, which are single and

[1] I am very grateful to Drs. H. C. Greene, J. C. Lindquist, K. H. McKnight, D. B. O. Savile and C. G. Shaw for loans and gifts of herbarium material.

scattered or aggregated and confluent. In cases of heavy infection the young leaves become stunted and malformed. The galls protrude conspicuously and are subcircular, oval, or elongate in cross section and vary from 300 to 1600μ in diameter. Depending on their size, they bear from 30 to several hundred resting sporangia. These are flattened on the lower surface and almost hemispherical or plano-convex in shape, 26–48 × 37–67μ in diameter, with a 3–4.2μ thick, dark orange- to amber-brown smooth wall and refractive content. A conspicuous tapering peg is present on the lower surface which is the remnant of the short filament which attached the sporangium to turbinate swelling. In some cases the shriveled turbinate swellings are still present, but no pits or marks are visible where presumably digitate haustoria were attached.

This species is probably *Physoderma pluriannulata* which is reported to occur on numerous hosts (Karling 1950). It is very similar to specimens of this species collected by Solheim (1936) on *Ligusticum simulans* in Wyoming which I (1950) studied cytologically. It may possibly prove to be a biological race of *P. pluriannulata* after cross inoculation studies on numerous different hosts have been made. In this connection it may be noted that the specimens of *P. pluriannulata* in most herbaria in this country still bear the label *Synchytrium pluriannulatum* in spite of Farlow's (1908) demonstration that it is not a species of *Synchytrium*. Cook (1951) reported that he found both *Synchytrium* and *Urophlyctis* (*Physoderma*) on *Sanicula canadensis*, and quite likely this report will be confirmed because species of *Synchytrium* occur on so many hosts. However, the fungus which Farlow (1885) first named *S. pluriannulatum* and later (1908) *Urophlyctis pluriannulatus* is not a species of *Synchytrium*. In all herbarium specimens bearing this label which I have examined so far no *Synchytrium* is present.

Physoderma on Parthenocissum quinquefolia. This species was found during an examination of herbarium specimens of *Synchytrium parthenocissi* which Cook (1953) collected in Louisiana. In addition to *S. parthenocissi* the author found numerous large, aggregated and occasionally confluent or scattered galls on both surfaces of the leaves which contained 40 to more than 100 resting sporangia of *Physoderma*. These are predominantly plano-convex or almost hemispherical, 28–34 × 44–52μ, with a 3–3.2μ thick, orange- to chestnut-brown, smooth wall and highly refractive content which includes one to several large refringent globules. Remnants of digitate haustoria are present in a ring around the upper surface, and parts of the rhizomycelium adhere to the lower surface. The galls are subcircular to circular in cross section and 280–800μ in diameter. The size and appearance of the sporangia are similar to those of *P. pluriannulata*,

but whether or not the two species are identical remains to be shown from further study.

Physoderma on Notosciadium pampicola. This species was collected by Spegazzini, 11-18-1923, in La Plata, Argentina, and labeled *Urophlyctis notosciadii*. Type material of this fungus was included among the *Synchytrium* specimens loaned to me by Dr. J. C. Lindquist of the Instituto Botanico Spegazzini, La Plata, Argentina. Like *P. alfalfae* it occurs principally on the host organs at ground level and causes marked stunting and distortion of the plants. The stems are shortened, and the leaves, flowers and fruits may become so malformed that they bear but little resemblance to their normal appearance. The galls may be single and scattered and subcircular to oval in cross section, 290–700μ, but they are usually aggregated and confluent and bear more than 1000 sporangia. In the latter cases, the galls are very large, and the infected organs are several times their normal diameter.

The sporangia are predominantly plano-convex, fairly uniform in size, 24–32 × 40–48μ, with a light-amber-brown, 2.8–3μ thick, smooth wall and coarsely granular refractive content. No haustoria are present, but remnants of shriveled swellings and the rhizomycelium are present on the lower surface. Inasmuch as this species has not been reported or described in the literature, as far as the author is aware, the following diagnosis is presented.

Physoderma notosciadii (Speg.) nov. comb. *Urophlyctis notosciadii* Spegazzini, 1923. In herb. Sporangiis predurantibus subglobosis vel plano-convex, 24–32 × 40–48μ, parietibus brunneis, 2.8–3μ crasso.

Resting sporangia numerous, 40–150 in small single gall, up to more than 1000 in confluent galls, plano-convex or almost hemispherical 24–32 × 40–48μ, with a light amber-brown, 2.8–3μ thick, smooth wall and coarsely granular refractive content. All else unknown. Galls numerous, usually aggregated and confluent, single and scattered galls protruding, predominantly oval to subcircular in cross section, 290–700μ diam.

On stems, petioles, leaves, flowers and fruits of *Notosciadium pampicola*, La Plata, Argentina, causing stunting and marked malformation of the infected organs.

Physoderma on Medicago arabica. This species was collected by Dr. R. A. Kilpatrick at Starkville, Miss., U.S.A., 4-8-1953, and sent to the herbarium of the University of Wisconsin. It induces numerous dark-brown to almost black, protruding, hemispherical galls on both surfaces of the leaves and on petioles which are scattered or aggregated and confluent. The latter type may cause marked local thickening of the petioles, and are usually oval to elongate, 300–500μ × 800–3000μ, in cross section and may contain more than 1000 resting sporangia. The smaller, single and

hemispherical galls vary from 380–500μ in diameter and may contain up to 200 resting sporangia. The latter are less flattened on the lower surface than those of the preceding species and vary from 28–37 × 38–48μ in diameter. They are golden to chestnut-brown in color with a 1.8–2.2μ thick smooth wall and coarsely granular refractive content.

The identity of this species is uncertain because several *Physoderma* species have been reported on leguminous hosts. *Physoderma alfalfae* has been reported on *Medicago sativa, M. falcata, M. rotata* and *M. denticulata* in several countries throughout the world (Karling 1950) by numerous workers, but its resting sporangia are usually larger than those of the present species. Furthermore, it causes marked malformation and stunting of the host, while the one on *M. arabica* causes only slight distortion. However, this difference is essentially a host reaction, and its taxonomic value is uncertain at present. Another parasite of leguminous hosts is *P. trifolii* which is reported to occur on *Trifolium pratense, T. repens, T. montanum, T. resupinatum* and possibly *T. incarnatum* and *Lotus corniculatus.* Its resting sporangia are smaller than those of *P. alfalfae* and more like those of the fungus on *M. arabica. Physoderma vagabunda* also has been reported on *Medicago denticulata* and *Adesmia punctata* in Argentina, and its sporangia are small, 20–22 × 38–40μ, like those on *M. arabica.* However, their wall is undulate and subverrucose instead of smooth. Whether or not the present species on *Medicago arabica* is identical or closely related to any of these species remains to be shown by further study involving living material and additional hosts.

Physoderma on Ranunculus pusillus. This species was found in the examination of herbarium material and Cook's prepared slides of *Synchytrium ranunculi* which he (1947) collected in Louisiana, and brief mention was made of its occurrence by me in 1955. No conspicuous *Physoderma* galls or spots are present on the material available, and the resting sporangia have been found only in close relation with the *Synchytrium* galls which are quite abundant. Apparently, the infection is limited and sparse. The resting sporangia are rather deep-seated in the host tissue, and only 1 to 3 are present in individual cells. These are almost hemispherical or plano-convex, 18–28 × 24–32μ diam., with a smooth light amber-brown wall, 2–2.5μ thick, and coarsely granular refractive content. Attached to the lower surface of the sporangia are remnants of the rhizomycelium, but no rhizoids are visible.

Physoderma on Claytonia megarrhiza. This species was collected by Dr. K. H. McKnight of Brigham Young University, 7-1-1955, at Upper Soapstone, Summit Co., Utah, who kindly gave me some of his herbarium material. Inasmuch as Dr. McKnight plans to make a detailed study of this species I am merely recording its occurrence and general character-

istics here. It usually causes broad cushion- or mound-shaped protuberances on the stems, petioles and floral parts, and the petioles may become almost twice their normal diameter in the region of infection. Also, the ovules are frequently infected and become enlarged. The protuberances are usually composed of greatly enlarged cells which contain from 30 to almost 100 resting sporangia. These are plano-convex, 18–22 × 20–30μ, chestnut-brown, with a dark-amber, smooth wall, 2–2.3μ thick, and usually contain numerous refractive granules or globules which may coalesce to form a large central one. The size and shape of the resting sporangia are fairly similar to those of *Physoderma claytoniana* which Green (1944) and Sparrow (1947) reported on *Claytonia virginica* in Wisconsin, Michigan and Ontario. In recent correspondence with me, Dr. D. B. O. Savile reported a species on the same host in Essex Co., Ontario with smaller resting sporangia which may possibly prove to be different from *P. claytoniana*.

Physoderma on Coniselinum chinensis. This species was collected by I. J. Bassett, 8-15-1947, near Tompkins, Codroy Valley, Newfoundland and temporarily identified as a species of *Synchytrium*. It causes scattered and isolated, reddish galls on the underside of the leaves which protrude conspicuously and are largely superficial on the host. They may be subspherical with a slightly constricted base, dome-shaped or subhemispherical, 168–420μ high by 192–600μ broad with a shallow apical depression, and resemble closely the galls caused by *Synchytrium*. The resting sporangia are not conspicuously plano-convex but almost oval, 26–36μ × 33–42μ, with an amber- to orange-brown, smooth wall, 2–2.6μ thick, and coarsely globular content.

Physoderma on Cicuta mackenzieana. This species was collected by J. A. Calder and J. M. Gillett, 8-1-1949, three miles east of Mayo, Yukon. It causes numerous discrete mound-shaped, 300–400μ high by 380–624μ broad, chestnut-brown to brownish-black protuberances on the leaves and stems. Its resting sporangia are plano-convex to oval, 16–23 × 21–30μ, with a light-amber, smooth wall, 1.9–2μ thick, and almost hyaline, refractive, globular content. The sporangia are enveloped by light-brown residue which tends to hold them together.

Physoderma on Cicuta douglasii. This species was collected by Calder and Savile, 7-23-1953, in a bog 4 miles southeast of Revelstoke, B. C. In the material at hand the host is not malformed or distorted by the infection, and the fungus manifests itself by the production of discrete, mound-shaped, brownish-black protuberances on the leaves and stems. These are composed of slightly enlarged cells which contain 3 to 12 resting sporangia of the fungus. The sporangia may be almost oval or slightly plano-convex, 15–19 × 18–24μ, with an almost hyaline wall, 2μ thick and coarsely globular refractive content. They appear to be light-amber to light-brown when

viewed en mass, but individual sporangia appear almost hyaline. The blackish-brown color of the galls or protuberances is due primarily to the brown residue around the sporangia in individual host cells, and when this is soaked away the wall of the sporangia is almost hyaline.

The three Canadian species described above occur on members of the Umbelliferae, and it is not certain from the information at hand that they are new species. Several other species, *P. pluriannulata, P. hemisphaericum, P. vagans, P. raysii* and *P. hydrocotylidis,* have been reported on several genera and species of this family, and the three present fungi may be identical to some of these if host specificity and host range prove to be taxonomically significant in *Physoderma.* However, the resting sporangia of the Canadian species are considerably smaller than those of *P. pluriannulata, P. hemisphaericum* and *P. raysii,* but fall within the size range of those reported for *P. vagans.* Also, like those of *P. vagans* they are more oval and less plano-convex than most species and comparatively few in number in individual host cells. On these grounds I am inclined to regard the Canadian species tentatively as *P. vagans,* but their identities remain to be proven. It should be emphasized here that the binomial *P. vagans* probably includes more than one species as Fischer (1892) and Minden (1911) pointed out. It has been reported on several families of host plants in Europe, but no host range studies have been made with the various collections.

Physoderma on Roripa islandica var. hispida. This species was collected by W. J. Cody and C. C. Loan, 7-11-1950, 1 mile south of Ft. Smith, Alta. Except for *P. vagans* on *Nasturtium amphibium* (Schroeter, 1882) in Germany, this is the only species found to occur on a member of the Cruciferae. It causes scattered or confluent oblong to sub-circular or irregular, mound-shaped, lavender-red to reddish-brown protuberances or galls on the leaves and petioles. These galls are composed of slightly enlarged host cells which contain 2 to 10 resting sporangia of the fungus. The sporangia are plano-convex to almost oval, 16–26 × 28–36μ, with a yellowish- to light-amber wall, 2u thick, and coarsely globular, refractive content. The wall of the sporangia is slightly darker than that reported for the species on *Coniselinum* and *Cicuta,* and the sporangia en mass appear chestnut-brown and fall within the size range of those of *P. vagans.* However, it is not certain from the information at hand that this species is identical to *P. vagans.*

Physoderma on Potentilla palustre var. parviflora. This species was collected at Chesterfield Inlet, Dist. of Keewatin, N.W.T. by D. B. O. Savile, 8-14-1950, who identified it as *P. comari.* It causes numerous separate or confluent, lavender-red, low mound-shaped protuberances on the leaves. Their cells, however, are enlarged only 1 to 3 times their normal

size and contain only 1 to 4 resting sporangia of the fungus. These are slightly plano-convex to ellipsoidal, 20–28 × 32–36μ, with smooth, hyaline to faintly-yellow, wall, 1.6–2μ thick, and coarsely globular refractive content. They are enveloped by a layer of protoplasmic residue which binds them together fairly tightly. The lavender-red color of the galls or protuberances is due to a pigment in the individual host cells, and when they are soaked over-night in water the pigment disappears. *Physoderma comari* has been reported only on *Comarium* (*Potentilla*) *palustre* in Europe and Iceland, and Savile's identification of the Canadian species as such is probably correct. Its resting sporangia are somewhat smaller than those reported for *P. comari* in Europe, but this difference may not be significant.

In addition to the previously unrecorded species of *Physoderma* described above, it may be noted that Bartholomew (1927) listed a *P. didermoides* without its host in Kansas. As far as I am aware this species has not been described and so far I have been unable to locate material of it for study. The present study of herbarium specimens indicates how commonly species of *Physoderma* occur in nature, and it is quite probable that its species will be found to be almost as numerous and widely distributed as those of *Synchytrium*.

SUMMARY

1. Eleven unrecorded species of *Physoderma* from various herbaria in the United States, Canada and Argentina are described on new hosts.

2. Only the endobiotic resting sporangial stage is present in these specimens, and nothing is known about ectobiotic evanescent sporangia, zoospores, and the germination of the resting sporangia.

3. Whether or not any of these species are new remains to be proven from more intensive developmental as well as host range studies. Several of them will probably prove to be identical to previously known species.

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ADDITIONS TO THE FIJIAN SPECIES OF PEPEROMIA

T. G. YUNCKER

In a study of specimens of *Peperomia* collected by Dr. A. C. Smith in Fiji in 1953,[1] the following four species and one variety are believed to be undescribed and to represent taxa new to science. Many of the Fijian species of *Peperomia* appear to be quite variable and do not always present strong differential characters. It has not been possible, however, to reconcile these new entities with any which have been treated in previous papers on the species of the genus as they occur in Fiji (Yuncker 1936, 1943, 1949).

Peperomia falcata Yuncker, sp. nov. (fig. 1). Herba epiphytica carnosa; caule simplice e basi decumbenti radicanti ad 40 cm. vel ultra; foliis seorsum alternis deorsum oppositis, elliptico-lanceolatis, apice falcatim longo-acuminatis, basi acutis ad cuneatis, supra glabris vel dissite basi tantum pubescentibus, venis subtus pubescentibus, palmatim 3–5-nerviis; petiolo gracili canaliculato, crispo-pubescenti; spicis immaturis axillaribus terminalibusve.

A succulent epiphytic herb, the unbranched stem 5 mm. thick at the base when dry, slender above, ascending to 40 cm. or more from a decumbent rooting base, crisp-pubescent, the hairs about 0.5 mm. long, the internodes about 1 cm. long above, becoming 4 cm. or more near the base. Leaves alternate above, opposite toward the base, elliptic-lanceolate, falcately long-acuminate, the base acute to cuneate, glabrous above or slightly pubescent along the midrib near the base, the nerves beneath pubescent, marginally ciliolate above the middle, palmately 3–5-nerved, or the innermost pair of lateral nerves slightly coalescent with the midrib near the base, 1–1.5 cm. wide and about 6 cm. long, the lower leaves somewhat smaller, drying membranous, translucent, dark above, paler beneath, the petiole slender, canaliculate, from 3 to 5 mm. long above to about 1 cm. on lower leaves, crisp-pubescent. Spikes as yet young, solitary, axillary or terminal, about 1 mm. thick and 1.5–1.7 cm. long, the peduncle slender, 3–5 mm. long, glabrous, the bracts round-peltate, the ovary ovoid, with apical [?] stigma.

Distribution: Known only from the type locality.

FIJI: Taveuni: Hills east of Somosomo, west of old crater occupied by small swamp and lake, alt. 660–900 m., in dense forest, Aug. 18, 1953, *A. C. Smith 8363a* (US, TYPE, as sheet no. 2191070).

The narrow, falcately acuminate leaves and the pubescence characterize this species. The spikes on the only specimen collected are young and solitary in the axils. It may prove that more mature specimens will

[1] This was Dr. Smith's third trip to the islands. It was made under the auspices of the National Science Foundation and the Smithsonian Institution.

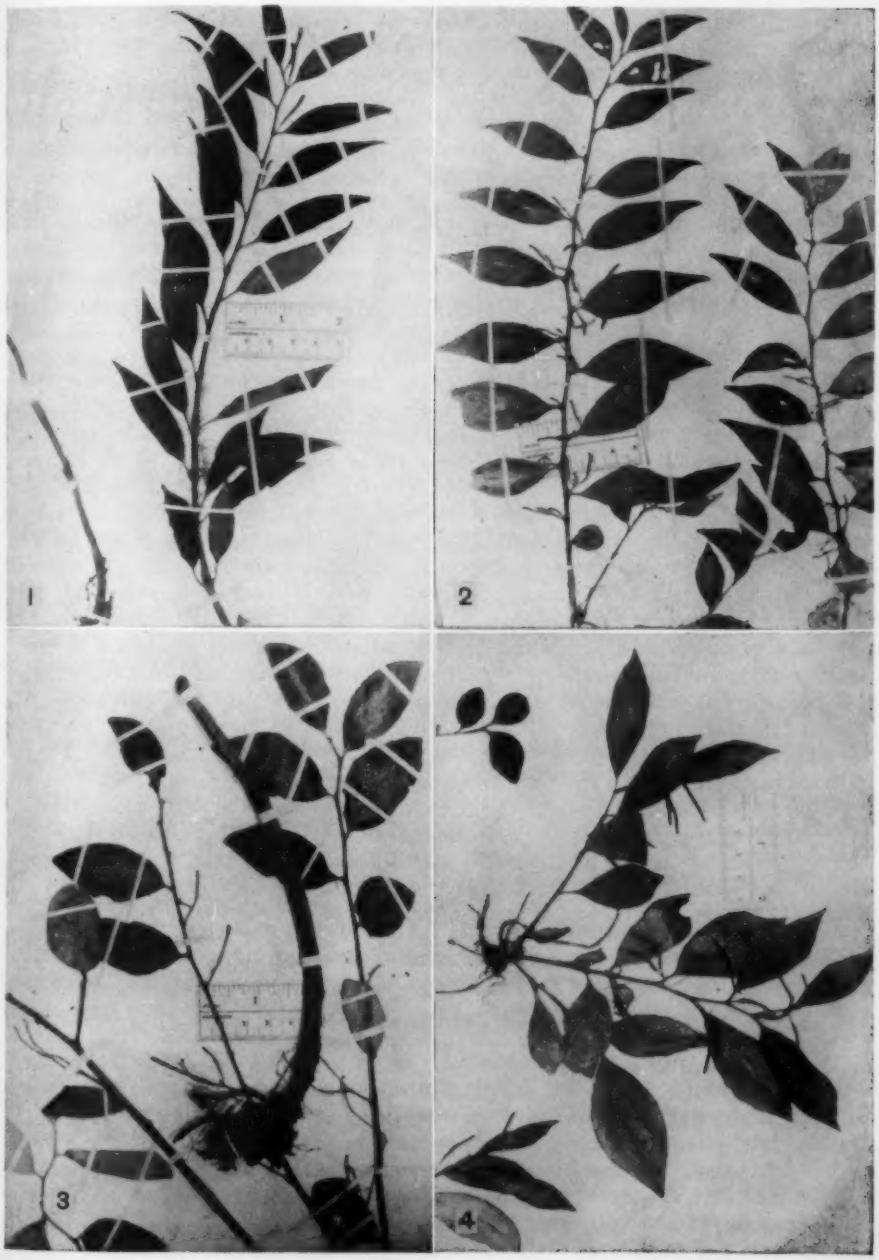

FIG. 1. *Peperomia falcata* Yuncker. FIG. 2. *P. disticha* Yuncker. FIG. 3. *P. namosiana* Yuncker. FIG. 4. *P. purpurinodis* Yuncker. Figs. 1–3 of the type specimens in Herb. US. Fig. 4 of an isotype specimen in Herb. DPU.

exhibit the branching type of inflorescence characteristic of a number of Fijian species, in which occasionally upper spikes may be solitary and lower ones multiple. From *P. lasiostigma* C. DC. and *P. attenuata* Yuncker, two species with which it appears to be most closely allied, this species differs in its pubescence, longer petioles, solitary [?] spikes, and falcately acuminate leaves.

Peperomia disticha Yuncker, sp. nov. (fig. 2). Herba epiphytica, caule e basi ramoso seorsum simplice, conferte crispo-pubescenti; foliis alternis distichis, ellipticis vel elliptico-lanceolatis, apice sat longo-acuminatis, subfalcatis, basi acutis, utrinque pubescentibus, palmatim 5-nerviis; petiolo usque ad 5 mm. longo; spicis 3–5 paniculatis axillaribus, turbinata vel subglobosa, stigmate apicali.

An herbaceous epiphyte, the stems branching from the base, simple above, up to 40 cm. or more tall and 3 mm. thick near the base when dry, the internodes 1 cm. long above to 2 cm. near the base, densely crisp-pubescent, the hairs 0.25 mm. or less long. Leaves alternate, distichous, elliptic or elliptic-lanceolate, the apex rather long-acuminate, subfalcate, the base acute, 1.5–2 (–2.5) cm. wide and 4–6 cm. long, the lower leaves may be smaller, crisp-pubescent above at the base and along the midrib, the paler lower surface pubescent, ciliolate throughout, palmately 5-nerved, the outermost pair of lateral nerves slender and reaching only to about the middle, drying thin, translucent, lacking glandular dots, the petiole 5 mm. or less long, crisp-pubescent, canaliculate. Spikes 1–1.5 cm. long and 1 mm. in diameter, in paniculately branched axillary clusters of 3–5 spikes, the inflorescence branches crisp-pubescent, the peduncle 2–3 mm. long, glabrous, the floral bracts round-peltate, the drupe turbinate or subglobose, about 0.75 mm. long, the stigma apical.

Distribution: Eastern Viti Levu and the adjacent island of Ovalau.

FIJI: Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m., in dense forest, Apr. 22, 1953, *A. C. Smith 7211* (US). Ovalau: Summit of Mt. Ndelaiovalau and adjacent ridge, alt. 575–626 m., in dense bush and thickets of crest, May 11, 1953, *A. C. Smith 7369* (US, TYPE, as sheet no. 2190291).

The crisp pubescence, 2-ranked leaves, and short spikes are distinctive features of this species. It bears some resemblance to *P. lasiostigma* C. DC. but differs in its pubescence, mostly shorter spikes, etc.

Peperomia namosiana Yuncker, sp. nov. (fig. 3). Herba carnosa epiphytica; caule usque ad 1 m. alto, seorsum ramoso, conferte hirtulo, pilis rigidis erectis; foliis alternis ellipticis, apice rotundatis vel abrupte acutis, basi acutis, utrinque pubescentibus, palmatim 5-nerviis, petiolo usque ad 5 mm. longo; spicis 3–5 paniculatis axillaribus, drupa turbinata vel subglobosa, stigmate apicali.

A rather large, succulent, epiphytic herb; stems up to 2 cm. in diameter and purplish near the base when growing, up to 1 m. high, branching and greenish upward, densely hirtellous, the hairs stiffly erect, scarcely 0.25 mm. long, the internodes 1–2 cm. in length above to 10 cm. near the base. Leaves alternate, elliptical, the apex rounded or slightly narrowed

and bluntly pointed, the base acute, 1.5–2.5 (–3) cm. in width and 3.5–5.5 cm. in length, occasional leaves may be smaller, moderately to densely pubescent beneath, the hairs erect, about 0.5 mm. long, hirtellous along the midrib above, the margin densely ciliate throughout, palmately 5-nerved, the nerves comparatively slender and branched upward with the ultimate nervules anastomosing, with a slender submarginal nerve throughout, drying membranous, translucent, dark above, paler beneath, the petiole scarcely 5 mm. long, canaliculate, densely hirtellous. Spikes in axillary, paniculately branching, usually 3-5-spicate clusters, 2–3 cm. long and 1 mm. in diameter, moderately to densely flowered, the peduncle about 5 mm. long, the peduncle and inflorescence branches densely hirtellous, the floral bracts round-peltate, the drupe turbinate or subglobose, about 0.8 mm. long, the stigma apical.

Distribution: Known only from the type locality.

FIJI: Viti Levu: Namosi; valley of Wainambua Creek, south of Mt. Naitarandamu, alt. 250–350 m., in dense forest, Oct. 5, 1953, *A. C. Smith 8829* (US, TYPE, as sheet no. 2191471).

The type of pubescence closely resembles that of *P. parhamii* Yuncker from which it differs in its larger size, obtuse and densely ciliated leaves, lack of glandular leaf-dots, etc. It bears some resemblance to *P. ciliifolia* Yuncker in the size and shape of the leaves. It differs in the apparent greater size of the more strongly branched plants and in the character of the indument, etc. In *P. ciliifolia* the hairs are mostly 0.5–1 mm. long, the nerves are slightly coalescent at the base, and the blades are dark-dotted.

Peperomia purpurinodis Yuncker, sp. nov. (fig. 4). Herba epiphytica; caule ad 15 cm. alto, e basi ramoso, nodis tumidis purpuratis, conferte hirtulis; foliis alternis ellipticis vel elliptico-subobovatis, apice attenuatis acutis, basi acutis ad cuneatis, utrinque hirtulis, conferte glandulosopunctatis, palmatim 7- vel 9-nerviis, petiolo ca. 5 mm. longo hirtulo; spicis solitariis vel 2–3 paniculatis axillaribus; drupa turbinata vel subglobosa, stigmate apicali.

An herbaceous epiphyte, up to 15 cm. tall, branching from the base, the stems about 4 mm. thick at the base when growing, the internodes mostly 1–2 cm. long, the "nodes swollen, deep purple, the upper internodes and spikes reddish" [these characters not apparent in the dry specimen], densely hirtellous, the hairs scarcely 0.25 mm. long, rigid, erect. Leaves alternate, elliptic or elliptic-subobovate, the apex attenuate, acute, or small, lower leaves rounded, obtuse, the base acute to cuneate, 1.5–3 cm. wide and 4–7 cm. long, the lowermost leaves commonly smaller, the blade dark and hirtellous above near the base and along the nerves, paler and hirtellous beneath, rather strongly glandular dotted, the dots orange-red in color, ciliolate at least toward the apex, palmately 7–9-nerved, the midrib and innermost lateral nerves branched upward, drying rather firm, subtranslucent, the margin narrowly revolute, the petiole about 5 mm. long, canaliculate, hirtellous. Spikes 2–5 cm. long and 1.5–2 mm. thick, single or 2 or 3 in paniculately branched axillary clusters, the inflorescence branches hirtellous, the peduncle about 3–5 mm. long,

slightly hirtellous glabrescent, the peduncle and rachis glandular dotted, the floral bracts round-peltate, the drupe about 0.75 mm. long, turbinate or subglobose, the stigma essentially apical.

Distribution: Known only from the type locality.

FIJI: Viti Levu: Namosi; hills east of Wainikoroiluva River, near Namuamua, alt. 50–200 m., in dense forest, Oct. 26, 1953, *A. C. Smith 9033* (US, TYPE, as sheet no. 2191634).

The indument closely resembles that of *P. parhamii* Yuncker from which it differs, however, especially in the size and shape of the 7–9-nerved leaves.

PEPEROMIA PARHAMII Yuncker var. **glabra** Yuncker, var. nov. Omnino glabra.

The specimen representing this variety strongly resembles *P. parhamii* in its type of branching and growth habit. It differs in being entirely glabrous with the exception of the ciliolate leaf apices. The leaves are ovate or ovate-lanceolate, 1–1.5 (–2.3) cm. wide and 2–3 (–3.5) cm. long.

Distribution: Known only from the type locality.

FIJI: Ovalau: summit of Mt. Ndelaiovalau and adjacent ridge, alt. 575–626 m., in dense bush and thickets of crest, May 11, 1953, *A. C. Smith 7377* (US, TYPE, as sheet no. 2190297).

In some respects *P. parhamii* resembles *P. vitiana* C. DC. In *P. parhamii* the hairs are rigidly erect, the stem branches appear to be shorter and less flexuous and the leaves are proportionately wider and less attenuately pointed than in *P. vitiana*. The present glabrous specimen appears to agree better with *P. parhamii* than with *P. vitiana*.

SUMMARY

1. Four species and one variety of *Peperomia* from Fiji are described as new. With these new additions, a total of 24 species and 11 varieties are now known for that group of islands.

DE PAUW UNIVERSITY
GREENCASTLE, INDIANA

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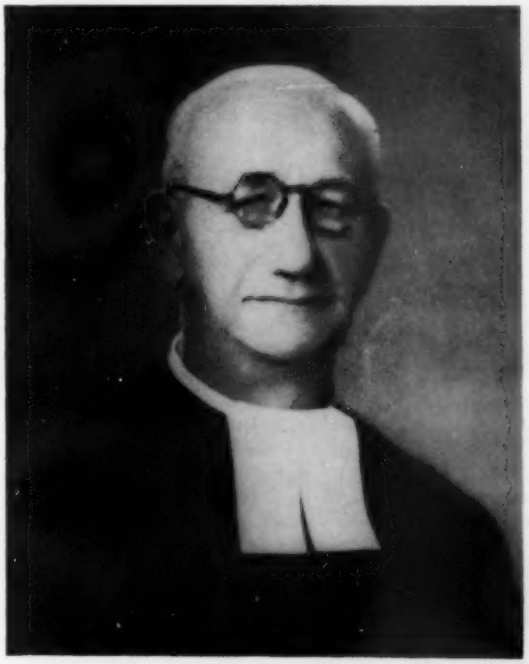
BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 83, No. 4, pp. 305–314 JULY, 1956

TORREYA

Brother Leon (Joseph Sylvestre Sauget)

Brother Leon died on November 20, 1955, near Havana. He was a most prominent Cuban botanist, author of the Flora of Cuba, and of many papers and pamphlets on Cuban plants. Born Joseph Sylvestre Sauget at Arbois, near Dijon, France, on December 31, 1871, he studied at the school in his native town, and later joined his teachers as a Brother of the Christian Schools. He volunteered to teach in foreign lands, as a missionary; and after spending one year in a school in Canada, he came to Havana in 1905. For 30 years, he was teaching at Colegio de La Salle, chiefly Biology; in his



Brother Leon (Joseph Sylvestre Sauget) December 31, 1871–November 20, 1955.

courses on Zoology and Botany he needed Cuban material to teach, and began gathering both animals and plants for the school museum.

Cuban Botany was little known in 1905. Only Charles Wright had explored some parts of Cuba systematically; La Sagra published a Flora in 1850, and Grisebach in Germany, after studying Wright's collections, published his "Catalogus Plantarum Cubensium" in 1866. With Sauvalle's "Flora de Cuba", published in Havana in 1869, this was all of the Cuban literature on Botany at the beginning of the century, when Brother Leon began his Herbarium.

At first, without books, reference Herbarium or even funds for his field trips, things were rather difficult. Only with Brother Leon's character may it be explained how he accomplished so much with so little during his whole life. During more than 15

years he sent his plants to Dr. N. L. Britton at the New York Botanical Garden, where they were studied and mounted, keeping one duplicate and returning the other. Dr. Britton was working with Percy Wilson and Brother Leon on a Catalogue of the Plants of Cuba, and intended to publish it; Brother Leon's work was very useful and added many observations used by the authors in the keys for the species. This manuscript was never published, but is now used in the writing of the Flora of Cuba, as a reference work.

Together with funds received from New York and the help of some friends, Brother Leon made many explorations in all parts of Cuba, finding many new species, that were described either by Dr. Britton, or by himself. The most important field trips were the ones in Banao Mountains, in the Province of Las Villas, between 1916 and 1918; in 1921 at Loma del Gato, Sierra Maestra, Oriente Province; in 1922 with Ekman (See Bull. Torrey Club 75: 444 and 79: 80–84.) he climbed the highest point in Cuba; this expedition alone yielded more than 50 species new to science; in 1924, he went near the eastern tip of the Island, in an unexplored region, the dryest part of Cuba, and in three weeks of intensive collecting, found many interesting and new species. Later on, he explored the northern part of Oriente, where grows the most endemic flora in Cuba.

His special fields of interest in Cuban Botany were chiefly grasses, palms, cacti and mosses. His interest in grasses began early and was helped by the finding of several new species, among them one in a new genus, *Saugetia fascicularis*, named after him; he sent all his grasses to Washington and Hitchcock and Chase cited them in their "Manual of the Grasses of the West Indies". He began seriously the study of Cuban palms in 1928, and published several pamphlets and booklets on the genera *Copernicia, Coccothrinax, Calyptrogyne, Acrocomia, Hemithrinax* and *Roystonea*. When he began his studies in the family, there were 39 known Cuban species of palms; now there are 77, and many new varieties, so he nearly duplicated the number of Cuban species of palms. Later on, in the early thirties, he began the study of Cuban cacti. He brought them from field trips, planted them in his garden, waiting for the flowers; he then made colored drawings of these flowers. He could only publish two or three papers on this family, but his studies were very valuable for the writing of the third volume of the Flora of Cuba, where these plants are treated. Brother Leon also published a "Catalogue des Mousses de Cuba", as a result of his studies in the mosses.

At the end of 1938, he had the visit of Brother Marie Victorin from the University of Montreal, author of "Flore Laurentienne", founder and director of the Montreal Botanical Garden. Both botanists began to travel in Cuba, making notes on the different ecological formations found throughout the Island, and taking many photographs of the plant life in Cuba. As a result of about five years of explorations, chiefly during the winter months, through savannas and woods, they published three books under the title: "Itinéraires Botaniques dans l'Ile de Cuba". These books have been highly praised both by botanists and non-botanists, for the scientific material and for the photographs and illustrations, as well as the very good literature found in them.

Brother Leon was about 70 years old when he decided to write down the "Flora De Cuba", his monumental work. In nearly 7 years, he completed the first volume, including the Monocotyledones, a book of 440 pages, with many photographs and drawings. The second volume was ready in 1951, though at that time, Brother Leon was not able to read any more, and had to leave the proof-reading to younger eyes. He still lived to see the third volume, in 1953, and the two remaining ones will be published when ready, as a memorial of his works in Cuban Botany.

From 1951 on, Brother Leon had to retire completely; his eyesight was getting worse, and his general health resented his old age. Though unable to work, he still hoped to get better and resume his work on the Flora of Cuba. He suffered from this forced inactivity, and was never able to rest completely. He dictated to a secretary a kind of autobiography, and still took interest in the plants he could find in the garden of the retiring house where he lived for three years outside Havana. Last August, he had to keep bed, and was unconscious for two or three days. He somewhat recovered

during September, but at the end of October he got worse and on November 20, he passed to a better life, where God will reward his works and sufferings.

His scientific work shows some 70 titles of papers or books about botany. He was very careful in his work, and never published anything without being completely sure of it. Considering that he has been working during more than 40 years without any official help and alone, that he was self-formed and self-educated, we must admire this character and strong will and look at his achievements as something unusual. He had teaching duties, and only on time taken out of his resting and vacation periods, has he been able to furnish such a great amount of work.

Brother Leon was a member of the Torrey Botanical Club, of the American Association for the Advancement of Science, of the Washington Academy of Sciences, of the American Association of Plant Taxonomists, of the International Association of Plant Taxonomists, of the Cactus & Succulent Society, of the Academy of Sciences of Bogota, and for a time a member of Société Linnéenne de Lyon. He was also nominated Honorary Member of the Botanical Society of America. In Cuba, he was a member of the Sociedad Cubana de Historia Natural Felipe Poey, of which he was vice-president for one term, and afterwards Honor President, member of Havana Academy of Sciences, and later member emeritus, member of Sociedad Cubana de Botánica, of Sociedad Cubana de Orquídeas, of Sociedad Forestal de Cuba, and was nominated Honor President of Sociedad Malacológica de Cuba; member of Sociedad Geográfica de Cuba and honored by the same Society with a gold medal. The Cuban Government nominated him as Officer of the National Order of Merit "Carlos Manuel de Céspedes", and the French Government gave him the title of "Officier d'Instruction Publique." Harvard University appointed him Research Associate, and he was also on the scientific staff of the Chicago Natural History Museum.

In 1927, he went to New York to receive the Honorary Degree of Doctor in Sciences at Columbia University. Havana University recognized also his merits in a solemn ceremony on October 19, 1951, conferring upon him the title of Doctor in Natural Sciences Honoris Causa.

Everybody that knew him insists on his kindness, though he had a very strong temper. His many friends were present at his burial, and let us hope that he is now resting in peace, after so many years of hard work and botanical explorations.—Brother Alain, Herbario De La Salle, Habana, Cuba.

Proceedings of the Club

Abstracts from the Minutes for 1955

January 18: See Bulletin of the Torrey Botanical Club (Torreya) 82: 237–241 and 250–252. May–June, 1955.

February 1: Mr. Raymond Wood presented a lecture: "A Season in the New Jersey Pine Barrens," illustrated by extraordinarily brilliant and handsome Ektachrome transparencies of the flora and vegetational types of the region. Refreshments were served by the staff of the New York Botanical Garden.

February 15: Dr. Michael Evanari of Hebrew University, Jerusalem, addressed the Club at Columbia University on "The Effect of Light on Germination," discussing the physiology of suppression or stimulation by light in seeds sensitive to it.

March 1: At Hunter College, Dr. Robert H. Whittaker of Brooklyn College presented a discussion of "Effects of Soil Parent-materials on Vegetation in the Siskiyou Mountains of Northern California."

March 15: Dr. Jack McCormick of Lebanon State Forest and the American Museum of Natural History presented a well-illustrated paper on "The Vegetation of the New Jersey Pine Barrens: An Interpretation." Refreshments were served by the staff of the New York Botanical Garden.

April 19: Dr. Evelyn Witkin of Cold Spring Harbor spoke at Columbia University on "Induced Mutations in Bacteria."

May 3: At Fordham University, Dr. B. M. Duggar discussed "The Hydrangeae

as a Source of an Ancient Chinese Alkaloid.'' Dr. Duggar spoke of the work he had done to discover American plants which could supply this alkaloid which had been used as an anti-malarial drug. Tea was served by the Biology Department at Fordham.

May 17: The meeting, at Columbia University, was called to order by President Lawton at 8:05 p.m.; 41 were present. The minutes of the preceding meeting were read and approved.

The following were elected Active Members: John Guccion, Richard T. Hanlin, Jack McCormick, Franc Ritter, Benjamin M. Sparrow, Howerd W. Swift, Oswald Tippo, R. Whittaker; Associate Members, Benjamin C. Adler, William P. Martin.

Dr. W. Ralph Singleton of the Brookhaven National Laboratory spoke on ''Radiation Induced Mutations in Corn and Carnations.''

October 15: The annual summer experience meeting followed dinner at the Rutgers University Commons. Members had earlier participated in the Dedicatory Exercises for the William L. Hutcheson Memorial Forest (formerly Mettler's Woods.)

November 15: Dr. Charles A. Berger presented a paper, ''Further Observations on the Cytology of *Xanthisma texanum.*'' This was followed by demonstrations and refreshments in the Fordham biology laboratories.

December 6: Dr. Karl Maramorosch of the Rockefeller Institute addressed the Club on ''Transmission of Plant Viruses by Insects'' at Columbia University. (See May–June, pp. 234–237 for this paper.)

Donald P. Rogers,
Recording Secretary.

With an occasional assist from H. W. Rickett, Honor M. Hollinghurst, and E. T. Moul.

1956

January 17: For report of Annual Meeting see page 240 (May–June number.) Yvan Carrier, Jeffrey G. Foley, and Thomas Lowery were elected to Active membership and N. C. Wyckoff was elected an Associate Member.

February 21: The meeting of the Club, at Columbia University, was called to order at 8:00 p.m. by President Barton. Thirty-four members and guests were present. The minutes of the previous meeting were read and approved. The following were elected to active (annual) membership: George G. Becker, Lionel D. Dureau, Miss Jean G. MacNab, Miss Joan E. Rahn, John R. Rowley, and Benjamin C. Stone. Mrs. Joan Newbourne was elected to associate membership. The resignation of several members and the death of one were noted with regret.

It was announced to the Club that Dr. Annette Hervey was elected by the Council to serve as Delegate to the New York Academy of Sciences. The members of the Club voted to fill two vacancies on the Council. Dr. Donald Rogers was elected to serve from 1954–1956 and Dr. Laura Kolk from 1955–1957.

Dr. Barton announced that a Program Committee had been elected by the Council to select speakers and arrange programs for the future meetings of the Club. The members of the Committee are: Clyde Chandler, Peter Nelson, Harold Rickett, John A. Small, J. Herbert Taylor, Robert Whittaker, and Eleanor Witkus.

Dr. Walter Tulecke of the Brooklyn Botanic Garden addressed the Club on, ''Observations on the Development in Vitro of *Ginkgo biloba* Pollen.'' The author's abstract follows.

The meeting was adjourned at 9:10 p.m.

Respectfully submitted,
Frank G. Lier
Recording Secretary

Observations on the Development in Vitro of *Ginkgo biloba* Pollen

The purpose of this work was to study the development of the male gametophyte of *Ginkgo biloba* in culture and to investigate the occurrence and the cytology of a tissue derived from the pollen.

Two sources of pollen were used for culturing: fresh pollen, which was cultured by surface-sterilizing intact strobili and placing them on the agar surface; stored pollen, which was obtained in powder form by causing the sterilized sporangia to dehisce in vials over calcium chloride at 5° C. The pollen was grown on several media, and the most successful one was a modified White's (1943) medium with 0.25% yeast extract and 1 mg. indole acetic acid per liter.

Development in culture paralleled the classical accounts of microgametogenesis given by Hirase (1898) and Herzfeld (1927) for development in the intact seed. Complete maturation was not achieved. Development proceeded only to the immature sperm cell stage and, in one instance, blepharoplasts differentiated to form spiral bands of two revolutions, but they lacked cilia.

Several types of abnormalities were observed in cultures. These included septate tube cells, multinucleate coenocytic gametophytes, intercalary divisions of the stalk and body cells and the outgrowth of a tissue from the germinated pollen.

The most striking abnormality was the tissue derived from the pollen. This tissue was isolated approximately once for each 800,000 to 1,000,000 pollen grains cultured. Upon transplantation to fresh media, the tissue proliferated very rapidly in most of the clones which were isolated. The tissue may be characterized as basically haploid in chromosome complement and consisting of many meristematic centers. After more than 20 subcultures the tissue has remained entirely parenchymatous and undifferentiated. The origin of the tissue appears to be from the tube cell of the gametophyte.—Walter R. Tulecke, Research Associate, Brooklyn Botanic Garden.

March 6: The meeting of the club, at Hunter College, was called to order by President Barton at 8:00 P.M. Twenty-four persons were present. The minutes of the previous meeting were read and approved.

Dr. John A. Small was elected by the Club to fill the unexpired term of Dr. Annette Hervey on the Council for the term 1955–1957. The Secretary was instructed to cast a unanimous ballot for the election of Dr. Small

President Barton introduced to the members the recommendation of the Program Committee and the Council dealing with the number of monthly meetings of the Club. The recommendation stated that the regular meeting of the Club was to be held on the first Tuesday of the month, and a second meeting on the third Tuesday if a speaker was available. If the first Tuesday fell on a holiday the regular meeting was to be on the third Tuesday. The members voted unanimously to accept this arrangement.

It was announced that Dr. David D. Keck had accepted the appointment as special representative of the Club at the coming New York Meetings of the A.A.A.S.

Dr. Robert Lampton of Upsala College, East Orange, New Jersey, addressed the Club on: "Some Observations on Cuban Wax Palms". A question and answer period followed the talk and members inspected the demonstrations provided by Dr. Lampton The author's abstract follows.

The meeting was adjourned at 9:00 P.M. Refreshments were served to the members by the Hunter College Faculty.

Respectfully submitted
Frank G. Lier
Recording Secretary

Natural waxes are still an important article of commerce and the carnauba wax from the carnauba palm of Brazil is one of the most important. This palm is *Copernicia cerifera*, Mart. and grows extensively only in Brazil.

The genus *Copernicia* is strictly American in its distribution and is represented by about 29 species spread through Brazil, Cuba, Columbia, Haiti, Paraguay, Santo Domingo and Venezuela. Of these 29 species of *Copernicia* 24 of them are Cuban. Distribution of these species on the island is widespread but in Camaguey province there are large areas of savannah lands on which several species of *Copernicia* may be found in large numbers.

So far as is known these species of *Copernicia* in Cuba have not been exploited commercially but the leaves and trunks are used locally for roofing thatch and building posts. Two species have leaves that are especially waxy and on the savannah areas around Camaguey City these two species hybridize freely and produce hybrid plants which exhibit excellent production of cuticle wax. These species of palms do not grow in dense stands which would make it practical to harvest the wax from the leaves.

The genus *Copernicia* in Cuba appears to be in a plastic state, species capable of interbreeding and definite specific characteristics difficult to determine.—Robert Lampton, Upsala College.

BOOK REVIEWS

Vascular Plants of the Pacific Northwest. Part 5: Compositae. By Arthur Cronquist. 343 pages. Completely illustrated. University of Washington Press, 1955. $7.50.

This first part to be completed in the projected five-part treatment, is filling a long-realized need. Except for the taxonomic area between Scrophulariaceae and Compositae, and though somewhat different in scope, it neatly supplements the three available volumes of Abrams' Illustrated Flora of the Pacific States, thus providing the first nearly complete flora of the Pacific Northwest. The remaining parts, when published, will of course supply the missing families and close the present geographical gap.

The Pacific Northwest, as defined in the Introduction, includes the state of Washington, the southernmost tip of British Columbia, the northern half of Oregon, northern Idaho, and the mountainous portion of Montana. In general the area is enclosed by rather natural boundaries. The southern line in western Oregon, for example, follows the Umpqua Divide which separates two distinctive floristic areas. On the other hand, the continuation of this across eastern Oregon makes of it an artificial boundary which might well have been dropped southward to the northern limits of the Klamath unit.

Dr. Cronquist's careful and authoritative descriptions, the complete bibliography, and his introductory sketch of his taxonomic philosophy, all contribute toward a publication of immeasurable value to botanists of the region. Usefulness of the book, both to the taxonomist and to the layman without technical training in the subject, is greatly enhanced by Dr. Rumely's clearly-defined drawings of each species. The high quality of the work makes one hesitate to suggest that any improvement is possible. However, certain minor modifications in the mechanics of the publication would, it is believed, counterbalance the added expense by increasing the reference value, as suggested below.

When expense is involved, there is no quarrel with the offset method of reproduction. The type is clean and clear and, for the most part, is of sufficient variety to meet the needs of clarity. Within the bibliography, the underlined names are easily picked up; and the happy arrangement of synonyms paragraphed according to the basonym is of additional assistance. But the reader must search for the accepted name of each species, since it is not set apart by size or weight of type or by an accompanying number. Bold-face type for these names, as well as for certain elements in the keys such as the generic groups (pp. 13 to 21), would greatly reduce lost time and motion. Incidentally, the indented keys are a source of satisfaction.

The alphabetical arrangement of genera and species is disturbing. If the book were designed primarily for the layman, an alphabetical arrangement of common names —provided standardization of these were possible, which it is not—might be justified. But it is difficult to see how alphabetizing scientific names, as is done here, can be of any use to the average layman; and it greatly lessens the value of the book to the taxonomist. Doubtless more expensive, but of obviously greater assistance to all concerned, would be the traditional arrangement accompanied by a complete index.

The use of common names is always tricky; but their application here mainly

to genera, with an occasional well-known species so designated, is a doubtful solution. At any rate, since their inclusion is of primary importance to the layman, their insertion after the technical specific description which he probably will not read, and in type indistinguishable from that of the text, is unfortunate. Indexing of common names only partially offsets this. Location of the common name immediately after the scientific name would be both logical and useful, especially if the two were set in contrasting type.

A final suggestion is that the professional position of each author be listed on the permanent title page rather than on the temporary jacket. Dr. Cronquist is Associate Curator of the Herbarium, New York Botanical Garden. From him we receive the welcome news that the text of Part Four is practically complete, and that the drawings should be ready for issuance of the book in 1957.—HELEN M. GILKEY.

How to Know the Fresh-water Algae. By G. W. Prescott. 211 pages. Wm. C. Brown Company, Dubuque, Iowa. 1954. Cloth bound $2.75; spiral bound $2.00.

Following the pattern of other of its predecessors in the "How to Know" series, this illustrated key adequately fulfills its purpose as stated on the title page—"An illustrated key for identifying the more common Fresh-water Algae to genus, with hundreds of species named and pictured and with numerous aids for their study."

Brief introductory sections—"What are algae?", "The phyla of algae", "Synopsis of the algal phyla", "How and where to collect fresh-water algae", "Preserving of algae"—are all of value to an interested amateur.

Decisions based upon color distinctions must of necessity be made early in the process of elimination involved in the use of a key to fresh-water algae. Aid in making such decisions which frequently involve difficult choices for the beginner is provided more adequately than in many keys by appropriately placed description and suggestions for comparisons. Because of its clarity and workability, the one available copy of the key when presented for trial to a summer class in algae made up largely of mature students was soon in constant demand. The many illustrations throughout the key are clear, accurate, and helpful and the species illustrated which represent the various genera are well-chosen. Dichotomy is adhered to throughout.

A selected list of references provides source material for those who wish to go beyond genus and the representative species which are illustrated and described in the body of the key.—RICHARD I. EVANS, Department of Botany, The University of Wisconsin.

Weeds of the North Central States. By the Editorial Subcommittee of the Regional Technical Committee of Project NC-10. 239 pages, keys, glossary. North Central Regional Publication No. 36. Circular 718 of the University of Illinois Agricultural Experiment Station, Urbana, Illinois. 1954.

This valuable publication describing a selection of 224 "weedy" plants is a commendable compilation by the editorial subcommittee under K. P. Buchholtz. The vegetative and reproductive organs of the "weeds" are clearly illustrated. For the greater majority of plants discussed, the gross habit, stem, leaf, root system, flower and fruit are shown. Distribution maps portray the species as: 1.) rare or absent; 2.) occasional to frequent; and 3.) general and common. The excellent yoked key by Duane Isely uses flower color as the chief identifying character which is probably as good a feature as any for the novice. The explanation of "What is a weed?" is good, but perhaps a few lines about the succession and ecology of "weeds" could have been included and mention made of the great number that have found their way to the United States with man as the disseminator.

Of the 224 species listed, the reviewer noted that 197 are found in the north-

eastern United States. It is of interest to observe that of the total number, 102 are endemics, 81 are of European origin, 5 are immigrees from Asia, 21 are native to Eurasia, 6 are indigenous to Tropical America and 1 is cosmopolitan to the tropics. Four of our native species (*Hordum jubatum, Silene antirrhina, Asclepias syriaca* and *Ambrosia psilostachya*) have been "exported" to Europe where they are now advancing and aggressive pests.

Hitchcock's revised (1950) "Manual of the Grasses" is used for the technical nomenclature of the grasses, "Gray's Manual of Botany" (8th edition) is used for all other plants but broomweed (*Amphiachris dracunculoides*) which is taken from Gates (1941) "Weeds of Kansas." If, as the authors of the publication state "The scientific names of plants . . . vary depending on the authority" why not cite one authority? Granted that all of Fernaldia is not universally accepted, but for consistency in the present manual it might be simpler to find all species in one reference book. The reviewer found that all the species but *Iva axillaris* are to be found in "Gray's eighth."

A few comments about two of the terms used are: "Perennial—lives several years," but the definition of several is two or three but not many—some of the perennials listed live for decades; and "Inflorescence—the entire group of flowers on a single plant," however, it is more correctly defined as mode of flower bearing. Omissions from the glossary which might be of value are the terms compound and umbel (three of the listed plants are umbelliferous). The 197 described and illustrated species present in the vicinity of metropolitan New York commend its inclusion in the libraries of the "city" botanists as well as for the use of persons who are vitally concerned with "weeds" as economic pests.—J. W. ANDRESEN, Department of Forestry, College of Agriculture, Rutgers, the State University of New Jersey.

An Introduction to Botany (new third edition). By A. W. Haupt. 447 pp. McGraw-Hill Book Co., Inc., New York. 1956.

This is one of the outstanding college textbooks in botany to be presented to the field in some time. It is designed primarily for a one semester course in which a solid foundation in the field is to be developed in the student. Part I covers morphology, physiology and ecology of seed plants, heredity and evolution. Part II deals with the systematics of the plant kingdom and the last chapter is on paleobotany. The book is well-balanced, clear, concise and fundamental. New material and illustrations have been added and the result is a crisp modern treatment of the science, but not at the expense of the fundamental material which has often happened in the past. New and old systems of classifications are presented and the basis of each is explained. In addition, the book has a glossary which will be very helpful to the beginning student. —DR. W. T. WARD.

General Biology. By Harrington Wells & Patrick Wells. 520 pp; McGraw-Hill Book Co., Inc., New York. 1956.

This book is well suited for life science or survey courses to be presented in a general education program. It includes the fundamentals of botany and zoology. For educators seeking a book of this type with emphasis on "biology *for* human beings and *not* human biology" the authors have provided an excellent text. It is exceptionally well illustrated and contains questions and problems for group discussions and reviews, suggested readings at the end of each chapter and an appendix which is a classification of the animal and plant kingdoms.—DR. W. T. WARD, Seton Hall University.

Luminescence of Biological Systems. Edited by Frank H. Johnson, American Association for the Advancement of Science, Washington, D. C. 1955. $7.00 ($6.00 to AAAS members.)

A rather diverse group of organisms, higher Basidiomycetes, fireflies, bacteria,

algae, and marine animals, have the common property of luminescence. The luminescence may come from the whole body, from a special organ, or from saprophytic bacteria living in an organ. One of the species of fish that has the latter type of illumination can shut off the light by drawing a dark membrane over the organ, since it has no control over the luminescent bacteria that provide the light.

The biochemistry of the production of such cold light has fascinated a diverse group of scientists for many years. Luminescent bacteria and *Cypridina* have been studied most.

About two-thirds of the thirty-four participants of a conference on luminescence in biological systems which was held in 1954 presented the papers published in this volume. Physical chemists, bacteriologists, biochemists, botanists, and zoologists contributed papers on dynamics of luminescence in chemical systems, green plants, bacteria, fireflies, and *Cypridina*. Considerable progress was reported in elucidating the biochemistries of the luminescence of *Cypridina* and bacteria. Three chapters are on ecology of various luminescent organisms.

Anyone interested in bioluminescence will find much of value in this book.—F. KAVANAGH, Indianapolis, Indiana.

Flora of Winnebago County, Illinois. By Egbert W. Fell. Nature Conservancy, Washington, D. C. 1955. 207 pp. Cloth, $3.50; paper, $2.75.

Present-day professional field-biologists often heave a nostalgic sigh for the "good old days" when many a country doctor, druggist, reverend, or high school teacher spent every minute of his spare time in a serious study of the native biota of his region, and came up with records both valuable to science and satisfying to the collector. Witness the Rev. Schweinitz, M. S. Bebb, nurseryman R. Bebb, businessman S. L. Wadmond, doctors Darlington, J. J. Davis, Gattinger, and Short and countless others. Their fame was partly due to the wealth of new species that they discovered. Their modern counterparts, rare, though by no means extinct, do not have this pleasure. Yet their work is none the less valuable, for today geographical and ecological distribution of species is recognized of prime importance and anyone who helps the full time biologist in accumulating such data for a small area is doing a valuable service. Furthermore, we have to be "mindful of the rapid changes which must accompany the passing of time and we believe that those who will come tomorrow will be interested in the conditions of today." It is, therefore, gratifying to see the publication of the FLORA OF WINNEBAGO COUNTY, ILLINOIS.

The author's botanical predecessors or colleagues who did much collecting in Winnebago County were M. S. Bebb (of *Salix Bebbii*), Evelyn Fernald and G. D. Fuller. Author Fell, a psychiatrist by profession, spent the past 35 years at his task to "become acquainted with the plants that live here" and to "have an intimate knowledge of our area and of its habitats."

A description of the county is found in the introduction, with notes on the cultural features (including a list of 19 forest preserves and parks—a total of 2,300 acres!), climate, geology, physiography, vegetation, types of habitat with lists of characteristic species, and a statistical analysis as to their probable geographic origin. A high percentage of the county was originally prairie with scattered woodlands as is characteristic of the prairie border region of Northern Illinois and Southern Wisconsin.

An annotated list of 1013 native and 197 introduced species makes up the bulk of the book, the natural history of each species being amply discussed as to its habitat, rarity, occurrence in the county, etc., starting with "*Lycopodium lucidulum*, very rare, being found in the county only in Winnebago-Boone County line woods and in a scrub black oak thicket in the north part of Shirland Township. Abundant in a few places on the sandstone at Castle Rock in Ogle County," and ending up with *Taraxacum vulgare*, which needs and has no comment. The 89 line drawings by the author are beautiful in their own, artistically primitive, way. Maps of the original

vegetation (woodland vs. prairie), the main geographic features of the county, and the position of the county within the state are printed on a loose sheet. It is regrettable that the author was not able to include detailed dot maps of the distribution of at least some species within the county. With his intimate knowledge that would not have been too difficult.

This labor of love has much to commend itself not only to the eager members of the Nature Study Society of Rockford and the amateurs of that region but also to the taxonomists and ecologists who take an interest in the Flora of the Middle West. It is in part by stepping stones such as these that some future botanist will be enabled to write the American equivalent to Hegi's Flora of Central Europe. Let's hope other naturalists will follow suit.—HUGH H. ILTIS, Department of Botany, University of Wisconsin.

NOTES

Dr. Paul R. Burkholder became director of research at Brooklyn Botanic Garden, 1000 Washington Avenue, Brooklyn 25, N. Y., on July 1. Already the discoverer of chloromycetin at Yale in 1947, Dr. Burkholder is searching for additional antibiotics. Other research at the Garden deals with tissue culture, physiology of lower plants, and a long-standing program in experimental horticulture.

Golden Jubilee Year is being observed by the BOTANICAL SOCIETY OF AMERICA. The climax will be reached at the time of the 51st Annual Meeting—August 26–30 at University of Connecticut, Storrs, Conn. Certificates of merit will be awarded. Distinguished speakers will further distinguish themselves, and special symposia will discuss, if not settle, important aspects of the botanical science.

The local representative at the University of Connecticut is Professor W. H. Camp. There will be field trips, some of them based at Camp Sargent, Petersborough, New Hampshire. Enjoy the view from Mt. Monadnock!

Nematologia was founded in July, 1955. The first issues are being filled with papers (30) read at the Third International Symposium, the subject of which was "Plant Nematodes and the Diseases They Cause." Published quarterly, it is expected that each volume will exceed 256 pages. The price is Dutch Gild 28.00 per volume (approximately $7.50). Address: Firma E. J. Brill, Oude Rijn 33a–35, Leiden, Holland.

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INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITORS OF THE TAXONOMIC INDEX

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